PHYSICAL SCIENCES Grade10 TERM 3 RESOURCE PACK

Contents

WORKSHEETS

Topic 17: Reactions of Aqueous Solutions

WORKSHEET

1. What is meant by the following terms?

1.1 Dissolving (3)

1.2 Hydration (3)

2. Write down balanced reaction equations for each of the following substances dissolving in water:

2.1 Na_2SO_4 (3)

2.2 $A\ell_2(CO_3)_3$ (3)

2.3 $Cu(NO_3)_2$ (3)

3. Describe the process by which ionic substances dissolve in water. (5)

4. **4.1** Describe a circuit which can be set up to determine whether solutions conduct electricity. (5)

4.2 What must be present in a solution for it to be able to conduct electricity? (1)

5. Write down balanced full ionic equations to represent the following reactions:

5.1 Lead(II) nitrate reacts with potassium iodide. (4)

5.2 Copper(II) chloride reacts with dihydrogen sulfide. (4)

6. **6.1** Describe a test that can be used to determine whether a solution possibly contains sulfate ions. (4)

6.2 Write down a balanced reaction equation that occurs during the test, if the solution contained potassium sulfate (K_2SO_4). (4)

7. **7.1** Describe a test that can be used to test for the presence of chloride ions in a solution. (4)

7.2 Write down a balanced net ionic equation to represent the reaction, if the solution contained magnesium chloride ($MgC\ell_2$). (3)

8. Three colourless solutions, A, B and C, contain potassium iodide, sodium carbonate and magnesium sulfate respectively. When barium chloride is added to solution A, the solution remains colourless. When barium chloride solution is added to B and C, a white precipitate is formed in both cases. When some dilute nitric acid is added to the precipitate in solution B, the precipitate dissolves.

Identify A, B and C. Give reasons for your choice. (5)

9. Why are precipitation reactions, gas forming reactions and acid base reactions described as ion exchange reactions? (2)

10. Identify the reaction types represented in each of the following equations:

10.1 $2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$

10.2 $2AgNO_3(aq) + CaC\ell_2(aq) \rightarrow 2AgC\ell(s) + Ca(NO_3)_2(aq)$

10.3 $2HNO_3(aq) + Mg(OH)_2(aq) \rightarrow Mg(NO_3)_2(aq) + 2H_2O(l)$

10.4 $Na_2CO_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + H_2O(l) + CO_2(g)$ (8)

CONSOLIDATION QUESTIONS

TOTAL: 73 MARKS

1. Write down balanced reaction equations for each of the following substances dissolving in water. Include phase symbols.

1.1 Ammonium nitrate (4)

1.2 Aluminium hydrogen sulfate (4)

1.3 Iron(III) dichromate (4)

2. **2.1** What is an electrolyte? (3)

2.2 Give an explanation for the fact that a solution of potassium chloride can conduct electricity. Make use of a balanced reaction equation in your explanation. (6)

3. **3.1** Give an explanation for the fact that even though sugar is soluble in water, a sugar solution does not conduct electricity. (3)

3.2 How do the following factors affect the conductivity of a solution?

3.2.1 The concentration of ions in a solution. (2)

3.2.2 The type of substance in a solution. (2)

4. **4.1** Describe a test that can be carried out to determine whether a solution contains iodide ions. (4)

4.2 Write down a balanced reaction equation for the test if the solution is sodium iodide. (4)

5. Write down balanced full ionic equations for the reactions between:

5.1 potassium bromide and silver nitrate. (4)

5.2 barium chloride and potassium carbonate. (4)

5.3 barium chloride and calcium sulfate. (4)

6. Silver nitrate reacts with HBr to produce a precipitate.

6.1 Name and give the colour of the precipitate formed during this reaction. (2)

6.2 Write down a balanced equation for this reaction. (4)

6.3 Write down an equation for the net ionic reaction that occurs. (3)

7. Two test tubes each contain a solution of either potassium carbonate or sodium sulfate.

7.1 Describe in detail how you would distinguish between the two solutions. (4)

7.2 Write down the equations for the reactions that occur in the test tube containing potassium carbonate during the tests which are carried out on it. (8)

7.3 Write down the equation for the reaction that occurs in the test tube containing sodium sulfate during the test which is carried out on it. (4)

MARKING GUIDELINES

1. **1.1** The process of dissolving occurs when solid crystals✓ break up into their ions or molecules✓in water.✓ (3)

1.2 Hydration is the process in which ions✓ become surrounded by water molecules✓ in aqueous solution. ✓ (3)

2. **2.1** $Na_2SO_4(s) \rightarrow 2Na^+(aq)$ ✓ + $SO_4^{2-}(aq)$ ✓ phases ✓ (3)

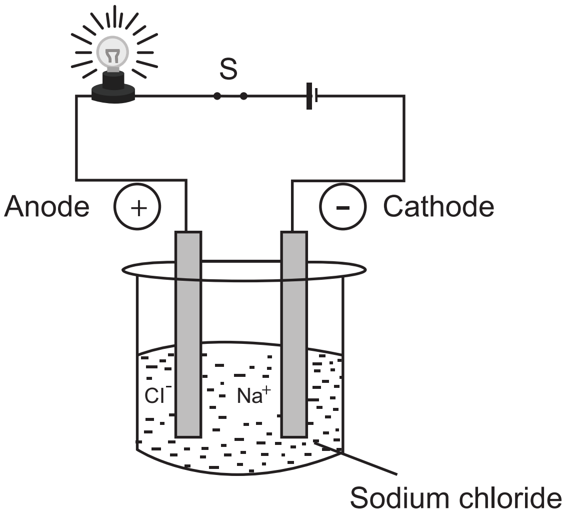
2.2 $A\ell_2(CO_3)_3(s) \rightarrow 2A\ell^{3+}(aq)$✓ + $3CO_3^{2-}(aq)$ ✓ phases ✓ (3)

2.3 $Cu(NO_3)_2(s) \rightarrow Cu^{2+}(aq)$ ✓ + $2NO_3^-(aq)$ ✓ phases ✓ (3)

3. When ionic compounds are placed in water, the positive ends of the water molecules are attracted to the anions✓ and the negative ends are attracted to the cations.✓ The combined attractions of the water molecules on the ions are sufficiently strong✓ to break the ionic bonds✓ and to remove the ions from the lattice. ✓ (5)

4. **4.1** The circuit consists of a battery or cell ✓connected in series with a switch✓ and a light bulb.✓ Also in series are two carbon electrodes✓ each of which is connected to the opposite terminals of the battery.✓ (5)

The illustration below is for clarity:



4.2 For a solution to conduct electricity there must be ions✓ present in the solution. (1)

5. **5.1** $Pb^{2+}(aq) + 2NO_3^-(aq)$✓ + $2K^+(aq) + 2I^-(aq)$ ✓$\rightarrow PbI_2(s)$✓ + $2K^+(aq) + 2NO_3^-(aq)$✓ (4)

5.2 $Cu^{2+}(aq) + 2C\ell^-(aq)$✓ + $2H^+(aq) + S^{2-}(aq)$✓ $\rightarrow CuS(s)$✓ + $2H^+(aq) + 2C\ell^-(aq)$✓ (4)

Note that sulfides of the transition metals are generally insoluble in water.

6. **6.1** To test for the presence of sulfate ions in a solution, add a few drops of $BaC\ell_2$ solution✓ to the test solution. If a white precipitate forms,✓ add a few drops of dilute nitric acid.✓ If the precipitate does not dissolve,✓ the test solution contains sulfate ions. (4)

6.2 $K_2SO_4(aq)$ ✓ + $BaC\ell_2(aq)$✓ → $2KC\ell(aq)$ ✓ + $BaSO_4(s)$✓ (4)

7. **7.1** To test for the presence of chloride ions in a solution, add a few drops of $AgNO_3$✓solution to the test solution. If a white precipitate forms, ✓add a few drops of dilute nitric acid.✓ If the precipitate does not dissolve,✓ the solution contains chloride ions. (4)

7.2 $2C\ell^-(aq)$ ✓ + $2Ag^+(aq)$ ✓ → $2AgC\ell(s)$ ✓ (3)

Note that the other ions, Mg^{2+} and NO_3^- are also present but they are spectator ions.

8. The fact that barium chloride solution gives no precipitate indicates that solution A must be potassium iodide.✓ When barium chloride is added to potassium iodide, no insoluble substance is formed, ✓thus no precipitate. ✓

The precipitate formed in B and C dissolves in nitric acid in B but not in C. this indicates that B is sodium carbonate ✓and C must be magnesium sulfate.✓ (5)

9. They are called ion exchange reactions because the cations exchange anions ✓and the reaction occurs as a result of this exchange.✓ (2)

10. **10.1** Acid base reaction ✓✓ (A salt and water are formed.) (2)

10.2 A precipitation reaction ✓✓ (One of the products is a solid.) (2)

10.3 Acid base reaction ✓✓ (A salt and water are formed.) (2)

10.4 A gas forming reaction ✓✓ (One of the products is a gas.) (2)

CONSOLIDATION QUESTIONS

TOTAL: 73 MARKS

1. **1.1** $NH_4NO_3(s)$✓ → $NH_4^+(aq)$✓ + $NO_3^-(aq)$✓ phases ✓ (4)

1.2 $A\ell(HSO_4)_3(s)$ ✓ → $A\ell^{3+}(aq)$ ✓ + $3HSO_4^-(aq)$ ✓ phases ✓ (4)

1.3 $Fe_2(Cr_2O_7)_3(s)$ ✓ → $2Fe^{3+}(aq)$✓ + $3Cr_2O_7^{2-}(aq)$ ✓ phases✓ (4)

2. **2.1** An electrolyte is a solution✓ that contains ions ✓and can conduct electricity.✓ (3)

2.2 Potassium chloride dissolves in water by dissociating as shown in the equation below:
$KC\ell(s) \rightarrow K^+(aq) + C\ell^-(aq)$ ✓✓
The solution thus contains positive and negative ions. ✓The positive ions move to the negative electrode✓ and the negative ions move to the positive electrode. ✓This completes the circuit OR This constitutes a flow of charge through the circuit.✓ (6)

3. **3.1** Sugar dissolves in water but does not give rise to ions during the solution process. ✓There are no free charges that can move ✓to produce a current.✓ (3)

3.2 **3.2.1** The higher the concentration of ions in a solution, the greater the current through the solution.✓✓

3.2.2 The type of substance affects the current in that some ionic substances dissolve to a greater extent than others, thereby releasing more ions in solution, and making them better conductors. ✓ Other substances, such as sugar, do not release ions in solution and therefore do not conduct current.✓ (4)

4. **4.1** Add a few drops of silver nitrate solution to the test solution.✓ If a yellow precipitate forms,✓ add a few drops of dilute nitric acid.✓ If the precipitate does not dissolve,✓ the test solution contains iodide ions. (4)

4.2 $NaI(aq)$✓ + $AgNO_3(aq)$ ✓ → $AgI(s)$✓ + $NaNO_3(aq)$✓ (4)

5. **5.1** $K^+(aq) + Br^-(aq)$✓ + $Ag^+(aq) + NO_3^-(aq)$ ✓→ $AgBr(s)$✓ + $K^+(aq) + NO_3^-(aq)$✓ (4)

5.2 $Ba^{2+}(aq) + 2C\ell^-(aq)$✓ + $2K^+(aq) + CO_3^{2-}(aq)$✓ → $BaCO_3(s)$✓ + $2K^+(aq) + 2C\ell^-(aq)$✓ (4)

6. **6.1** A light yellow precipitate of silver bromide✓ is formed.✓ (2)

6.2 $AgNO_3(aq)$✓ + $HBr(aq)$ ✓ → $AgBr(s)$✓ + $HNO_3(aq)$✓ (4)

6.3 $Ag^+(aq)$✓ + $Br^-(aq)$✓ → $AgBr(s)$✓ (3)

7. **7.1** Add a few drops of barium chloride solution to each test tube.✓ In both test tubes a white precipitate will appear.✓ Now add a few drops of dilute nitric acid to each test tube.✓ The test tube in which the precipitate dissolves is the potassium carbonate solution.✓ (4)

7.2 $BaC\ell_2(aq)$ ✓ + $K_2CO_3(aq)$✓ → $BaCO_3(s)$ ✓ + $2KC\ell(aq)$✓
$BaCO_3(s)$ + $2HNO_3(aq)$✓ → $Ba(NO_3)_2(aq)$✓ + $CO_2(g)$ ✓ + $H_2O(l)$✓ (8)

7.3 $BaC\ell_2(aq)$✓ + $Na_2SO_4(aq)$ ✓ → $BaSO_4(s)$✓ + $2NaC\ell(aq)$✓ (4)

Topic 18: Quantitative Aspects of Chemical Change

WORKSHEET

1. What is meant by each of the following terms?

1.1 Molar mass (2)

1.2 Relative formula (or molecular mass) (3)

1.3 A mole (3)

2. **2.1** What is the SI unit for amount of substance? (1)

2.2 Calculate the relative molecular mass of:

2.2.1 H_2CO_3 (2)

2.2.2 $CC\ell_4$ (2)

3. **3.1** Calculate the relative formula mass of the following substances:

3.1.1 $CaSO_4$ (2)

3.1.2 $KMnO_4$ (2)

3.2 Calculate the molar masses of the following substances:

3.2.1 $K_2Cr_2O_7$ (3)

3.2.2 H_3PO_4 (3)

4. Calculate the following quantities:

4.1 The number of moles in 200 g of water. (3)

4.2 The mass of 3,60 moles of NO_2 gas. (3)

4.3 The number of moles of molecules in 8,96 dm^3 of nitrogen gas at STP. (3)

5. 10 g of a pure sample of a specific compound is found to contain 4,0 g of carbon, 0,67 g of hydrogen and 5,33 g of oxygen. Determine the empirical formula of the compound. (5)

6. Calculate the percentage of water of crystallisation in $Na_2CO_3 \cdot 10H_2O$. (4)

7. Sulfur(IV) oxide reacts with oxygen gas according to the following balanced reaction equation:

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

6 moles of SO_2 react with oxygen in a closed container. Calculate:

7.1 the number of moles of $SO_3(g)$ that form when all the $SO_2(g)$ reacts. (2)

7.2 the total volume of gas in the container when the reaction is complete. (4)

8. Aluminium burns in chlorine according to the following balanced reaction equation:

$$2A\ell(s) + 3C\ell_2(g) \rightarrow 2A\ell C\ell_3(s)$$

Calculate the volume (at STP) of $C\ell_2(g)$ required to react completely with 30 g of aluminium metal according to the equation given. (5)

9. Nitrogen monoxide and carbon monoxide react according to the following balanced reaction equation:

$$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$$

50 g of NO(g) react completely. Calculate:

9.1 the mass of carbon dioxide which is produced. (4)

9.2 the volume of nitrogen gas produced at STP. (4)

10. Tin(IV) oxide reacts with hydrogen gas according to the following balanced reaction equation:

$$SnO_2(s) + 2H_2(g) \rightarrow Sn(s) + 2H_2O(g)$$

Calculate the mass of Sn(s) produced when 4,48 dm^3 of hydrogen gas reacts completely at STP. (5)

CONSOLIDATION QUESTIONS

TOTAL: 69 MARKS

1. **1.1** Define the term "molar volume". (2)

1.2 Calculate the number of moles in 2,24 dm^3 of neon gas at STP. (3)

1.3 Calculate the volume occupied by 5,6 g of nitrogen gas at STP. (5)

2. A solution is made up by dissolving 12,5 g of magnesium fluoride in sufficient water to make up 0,5 dm^3 of solution. Calculate the concentration of the solution. (4)

3. It is necessary to make up a solution of oxalic acid $(COOH)_2$ in the laboratory. The concentration of the solution must be 0,1 $mol \cdot dm^{-3}$. The container available for making up the solution has a volume of 0,25 dm^3. Calculate the mass of oxalic acid required for the solution. (5)

4. Determine the percentage composition by mass of $KMnO_4$. (4)

5. **5.1** What is meant by the term "empirical formula"? (3)

5.2 A sample of a compound is found to contain 6 g of carbon, 0,5 g of hydrogen and 17,75 g of chlorine. Determine the empirical formula of the compound. (5)

6. Determine the empirical formula of compound which has the following percentage composition by mass:

Cr = 35,37%

K = 26,53%

O = 38,10% (5)

7. **7.1** Calculate the number of moles of oxygen atoms in 196 g of H_2SO_4. (4)

7.2 Calculate the mass of 8,4 mol of NH_3. (3)

8. Urea is a fertiliser made by the reaction of ammonia with carbon dioxide according to the following balanced reaction equation:

$$2NH_3(g) + CO_2(g) \rightarrow (NH_2)_2CO(s) + H_2O(g)$$

800 g of $CO_2(g)$ reacts completely with ammonia. Calculate:

8.1 the mass of urea, $(NH_2)_2CO$, that is produced. (5)

8.2 the volume of $H_2O(g)$ produced at STP. (3)

9. The balanced chemical equation for the reaction that occurs when hydrogen gas and oxygen gas react is:

$$2H_2(g) + O_{2(}g) \rightarrow 2H_2O(g)$$

9.1 How many moles of oxygen gas react with 0,5 mol of hydrogen gas? (1)

9.2 24 g of oxygen gas react completely, calculate the mass of water vapour that is formed. (5)

9.3 If 50 dm^3 of oxygen gas react completely. Calculate the volume of water vapour produced in this reaction at STP. (5)

10. The balanced reaction equation represents the reaction that occurs when methane gas burns in air:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

10.1 What is the SI unit for amount of matter? (1)

10.2 How many moles of methane react with oxygen to produce 6 moles of water? (1)

10.3 Calculate the mass of carbon dioxide produced if 48 g of oxygen gas react completely with methane. (5)

MARKING GUIDELINES

1. **1.1** Molar mass is the mass of one mole of any substance, expressed in grams.✓✓ (2)

1.2 Relative formula or molecular mass is the sum of the relative atomic masses✓ of each of the atoms✓ making up a formula unit or a molecule.✓ (3)

1.3 One mole is the amount of substance ✓that contains as many elementary particles✓ as there are atoms in 12 g of carbon-12. ✓ (3)

2. **2.1** The SI unit for amount of substance is the mole. ✓ (1)

2.2 **2.2.1** $M_r(H_2CO_3) = (2 \times 1) + 12 + (3 \times 16)$✓

$= 62$✓ (N.B. no units) (2)

2.2.2 $M_r(CC\ell_4) = 12 + (4 \times 35{,}5)$✓

$= 154$ ✓ (No units) (2)

3. **3.1** **3.1.1** $M_r(CaSO_4) = 40 + 32 + (4 \times 16)$✓

$= 136$ ✓ (No units)✓ (2)

3.1.2 $M_r(KMnO_4) = 39 + 55 + (4 \times 16)$ ✓

$= 158$ ✓ (No units) (2)

3.2 **3.2.1** $M(K_2Cr_2O_7) = (2 \times 39) + (2 \times 52) + (7 \times 16)$✓

$= 294\ g{\cdot}mol^{-1}$ ✓✓ (3)

3.2.2 $M(H_3PO_4) = (3 \times 1) + 31 + (4 \times 16)$ ✓

$= 98\ g{\cdot}mol^{-1}$ ✓✓ (3)

4. **4.1**
$$n(H_2O) = \frac{m}{M}$$
$$= \frac{200}{18}$$
$$= 11{,}11 \text{ mol} \checkmark \text{of molecules} \checkmark$$
(3)

4.2
$$n = \frac{m}{M}$$
$$m = n \times M$$
$$= 3{,}6 \checkmark \times 46 \checkmark$$
$$= 165{,}6 \text{ g} \checkmark$$

$M(NO_2) = 14 + (2 \times 16)$
$= 46\ g{\cdot}mol^{-1}$

(3)

4.3
$$n = \frac{V}{V_m}$$
$$= \frac{8{,}96}{22{,}4} \checkmark\checkmark$$
$$= 0{,}4 \text{ mol} \checkmark$$

5. First calculate the number of moles of each element:

$$n_C = \frac{m}{M} = \frac{4}{12} = 0{,}33\checkmark$$

$$n_H = \frac{m}{M} = \frac{0{,}67}{1} = 0{,}67\checkmark$$

$$n_O = \frac{m}{M} = \frac{5{,}33}{16} = 0{,}33\checkmark$$

Dividing by 0,33 gives a ratio of C:H:O = 1: 2: 1✓

Empirical formula is CH_2O ✓ (5)

6. First calculate the molar mass of the compound:

$$M[Na_2CO_3{\cdot}10H_2O] = (2\times 23) + 12 + (3\times 16) + 10[(2\times 1) + 16]$$
$$= 286\ g{\cdot}mol^{-1}\checkmark$$

Now calculate the molar mass of the water:

$$M(H_2O) = 10(2\times 1) + 16$$
$$= 180\ g{\cdot}mol^{-1}\checkmark$$

$$\%\ water = \frac{180}{286}\checkmark$$
$$= 62{,}94\ \%\checkmark$$

(4)

7. **7.1** According to the balanced equation 1 mol SO_2 produces 1 mol SO_3✓

So, 6 mol SO_2 produces 6 mol SO_3. ✓ (2)

7.2 When the reaction is complete only SO_3 is present in the container, i.e. 6 mol SO_3.✓

$$n = \frac{V}{V_m}\checkmark$$
$$V = n \times V_m$$
$$= 6\checkmark \times 22{,}4\checkmark$$
$$= 134{,}4\ dm^3\checkmark$$

(4)

8. First calculate the number of moles of aluminium:

$$n = \frac{m}{M}$$
$$= \frac{30}{27}\checkmark$$
$$= 1{,}11\ mol\checkmark$$

According to the equation, 2 mol Aℓ reacts with 3 mol $C\ell_2$

So, 1,11 mol Aℓ reacts with 1,11 × 3/2 mol $C\ell_2$ = 1,67 mol $C\ell_2$ ✓

$$m(C\ell_2) = n \times M$$
$$= 1{,}67 \times 71\checkmark$$
$$= 118{,}57\ g\ of\ C\ell_2\checkmark$$

(5)

9. **9.1** First convert the NO to moles:

$$n = \frac{m}{M}$$
$$= \frac{50}{30} ✓$$
$$= 1,67 \text{ mol} ✓$$

From the equation we see that 1 mol NO produces 1 mol CO_2

So, 1,67 mol NO produces 1,67 mol CO_2 ✓

$$m(CO_2) = n \times M$$
$$= 1,67 \times 44 ✓$$
$$= 73,48 \text{ g} ✓$$

(4)

9.2 We now look at the mole ratio of NO to N_2:

2 mol NO produces 1 mol N_2 ✓

1,67 mol NO produces 0,835 mol N_2 ✓

$$n(N_2) = \frac{V}{V_m}$$
$$v = n \times V_m$$
$$= 0,835 \times 22,4 ✓$$
$$= 18,70 \text{ dm}^3 ✓$$

(4)

10. Begin by converting the volume to moles:

$$n = \frac{V}{V_m}$$
$$= \frac{4,48}{22,4} ✓$$
$$= 0,2 \text{ mol} ✓$$

2 mol H_2 produces 1 mol Sn

0,2 mol H_2 produces 0,1 mol Sn✓

$$m(Sn) = n \times M$$
$$= 0,1 \times 118,7 ✓$$
$$= 11,87\text{g} ✓$$

(5)

CONSOLIDATION EXERCISE

TOTAL: 69 MARKS

1. **1.1** Molar volume is the volume occupied by one mole of any gas at STP.✓✓ (2)

1.2 $n = \frac{V}{V_m}$ ✓

$= \frac{2,24}{22,4}$ ✓

$= 0,1 \text{ mol}$ ✓ (3)

1.3 First calculate the number of moles of nitrogen gas:

$n = \frac{m}{M}$

$= \frac{5,6}{28}$ ✓✓

$= 0,2 \text{ mol}$ ✓

Now calculate the volume of the gas:

$V = n \times V_m$

$= 0,2 \times 22,4$ ✓

$= 4,48 \text{ mol}$ ✓ (5)

2. First calculate the number of moles of magnesium fluoride:

$n = \frac{n}{M}$

$= \frac{12,5}{62}$ ✓

$= 0,2 \text{ mol}$ ✓

$M(MgF_2) = 24 + (2 \times 19)$
$= 62 \text{ g·mol}^{-1}$

Now calculate the concentration:

$c = \frac{n}{V}$

$= \frac{0,2}{0,5}$ ✓

$= 0,4 \text{ mol·dm}^{-3}$ ✓ (4)

3. First calculate the number of moles of oxalic acid required:

$n = c \times V$

$= 0,1 \times 0,25$ ✓

$= 0,025 \text{ mol}$ ✓

Now calculate the mass of oxalic acid:

$m = n \times M$

$= 0,025$ ✓ $\times 90$ ✓

$= 2,25 \text{ g}$ ✓

$M(COOH)_2 = 2(12 + 6 + 16 + 1))$
$= 90 \text{ g·mol}^{-1}$

(5)

4. First determine the molar mass:

$M(KMnO_4) = 39 + 55 + (4 \times 16)$

$= 158\ g{\cdot}mol^{-1}$ ✓

$\%K = \frac{39}{158} \times 100 = 24,68\ \%$ ✓

$\%Mn = \frac{55}{158} \times 100 = 34,81\ \%$ ✓

$\%O = \frac{64}{158} \times 100 = 40,50\ \%$ ✓ (4)

5. **5.1** The empirical formula is the lowest whole number ratio✓ in which atoms combine✓ to form a compound.✓ (3)

5.2 First determine the number of moles of each element present:

$n_C = \frac{m}{M} = \frac{6}{12} = 0,5$ ✓

$n_H = \frac{m}{M} = \frac{1,5}{1} = 1,5$ ✓

$n_{Cl} = \frac{m}{M} = \frac{17,75}{35,5} = 0,5$ ✓

Mole ratio C: H: Cℓ = 0,5: 1,5 : 0,5 (divide through by 0,5)

Whole number ratio is 1: 3: 1 ✓

Empirical formula is $CH_3Cℓ$ ✓ (5)

6. Assuming there is a 100 g sample, then we have 35,37 g of Cr, 26,53 g of K and 38,10 g of O.

Now calculate the number of moles of each:

$n_{Cr} = \frac{m}{M} = \frac{35,37}{52} = 0,68$ ✓

$n_K = \frac{m}{M} = \frac{26,53}{39} = 0,68$ ✓

$n_O = \frac{m}{M} = \frac{38,10}{16} = 2,38$ ✓

Mole ratio = 0,68: 0,68: 2,38 (divide through by 0,68)

Mole ratio = 1: 1: 3,5 and we still don't have a whole number ratio. In this case, to make it a whole number ratio, we can multiply everything by 2, so we will have a ratio of 2: 2: 7 ✓

Empirical formula is $K_2Cr_2O_7$ ✓

Remind learners of the need to write the elements in order from left to right across the Periodic Table. (5)

7. **7.1** First calculate the molar mass of H_2SO_4:

$M(H_2SO_4) = (2 \times 1) + 32 + (4 \times 16)$

$= 98\ g{\cdot}mol^{-1}$ ✓

Now calculate the number of moles of H_2SO_4:

$$n(H_2SO_4) = \frac{m}{M}$$
$$= \frac{196}{98} ✓$$
$$= 2\ \text{mol} ✓$$

Each molecule of H_2SO_4 contains 4 oxygen atoms, so each mole of H_2SO_4 molecules contains 4 mol of oxygen atoms. So 2 mol H_2SO_4 contains 8 mol of oxygen atoms.✓

(4)

7.2 $M(NH_3) = 14 + (3 \times 1)$

$= 17\ g{\cdot}mol^{-1}$✓

$$m = n \times M$$
$$= 8{,}4 \times 17 ✓$$
$$= 142{,}8\ \text{g} ✓$$

(3)

8. **8.1** First calculate the number of moles of CO_2 used:

$$n = \frac{m}{M}$$
$$= \frac{800}{44} ✓$$
$$= 18{,}18\ \text{mol} ✓$$

1 mol CO_2 produces 1 mol urea

18,18 mol CO_2 produces 18,18 mol urea✓

$$m = n \times M$$
$$= 18{,}18 \times 60 ✓$$
$$= 1\,090{,}8\ \text{g} ✓$$

$M(NH_2)_2CO = 2(14 + 2) + 12 + 16$ $= 60\ g{\cdot}mol^{-1}$

(5)

8.2 1 mol CO_2 produces 1 mol H_2O

18,18 mol CO_2 produces 18,18 mol H_2O✓

$$V = n \times V_m$$
$$= 18{,}18 \times 22{,}4 ✓$$
$$= 407{,}23\ \text{dm}^3 ✓$$

(3)

9. **9.1** 0,25 mol ✓ (1)

9.2 First calculate the number of moles of oxygen gas:

$$n = \frac{m}{M}$$
$$= \frac{24}{32} \checkmark$$
$$= 0,75 \text{ mol} \checkmark$$

1 mol O_2 produces 2 mol water

0,75 mol O_2 produces 1,5 mol water ✓

$$m = n \times M$$
$$= 1,5 \times 18 \checkmark$$
$$= 27 \text{ g} \checkmark$$

(5)

9.3 First calculate the number of moles of oxygen gas:

$$n = \frac{V}{V_m}$$
$$= \frac{50}{22,4} \checkmark$$
$$= 2,32 \text{ mol} \checkmark$$

2,32 mol O_2 produces 4,64 mol water ✓

$$V = n \times V_m$$
$$= 4,64 \times 22,4 \checkmark$$
$$= 103,94 \text{ dm}^3 \checkmark$$

(5)

10. **10.1** The SI unit for the amount of matter is the mole. ✓ (1)

10.2 3 moles of methane ✓ (1)

10.3 First calculate the number of moles of oxygen gas:

$$n = \frac{m}{M}$$
$$= \frac{48}{32} \checkmark$$
$$= 1,5 \text{ mol} \checkmark$$

2 mol O_2 produce 1 mol CO_2

1,5 mol O_2 produce 0,75 mol CO_2 OR 0,75 mol O_2 produces 1,5 mol water ✓

$$m = n \times M$$
$$= 0,75 \times 44 \checkmark$$
$$= 33 \text{ g} \checkmark$$

(5)

Topic 19: Vectors and Scalars

WORKSHEET

1. There are two types of physical quantities that we measure in physics: vectors and scalars.

1.1 Clearly distinguish between a vector and a scalar quantity. (3)

1.2 Explain why force is a vector quantity. (1)

1.3 Classify the following quantities as vectors or scalars.

1.3.1 volume

1.3.2 mass

1.3.3 time

1.3.4 change of position

1.3.5 direction

1.3.6 weight (6)

2. John pushes a crate forwards by exerting a horizontal force of 90 N on it. A frictional force of 36 N (between its surface and the floor) acts on the crate horizontally in the opposite direction.

2.1 Using a dot to represent the crate, draw a scale diagram of the two horizontal forces acting on the crate. (Show the scale which you use.) (4)

2.2 Determine the resultant force acting on the crate. (4)

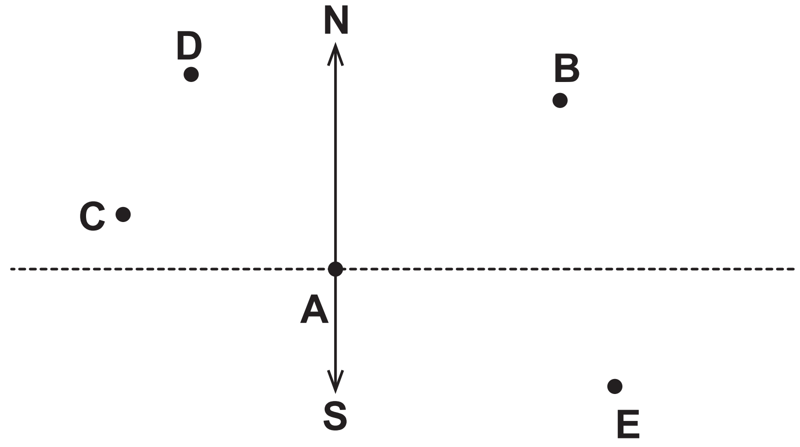
3. A plane flies 500 km east in a straight line from town A to town B. The plane lands at town B, and then it flies 1 000 km west in a straight line from town B to town C.

The displacement of the plane is a measure of its change in position. Displacement is a vector quantity.

3.1 Define “a vector quantity”. (2)

3.2 Using a scale diagram determine the resultant displacement of the plane from town A to town C. (4)

4. An ant walks to and fro over the kitchen table picking up grains of sugar on its way. The points (A, B, C, D and E) to which it travelled are shown in the scale diagram below.



Scale: 1 cm: 2 cm

4.1 Draw displacement vectors from each point to the other, following the sequence of from A to B, from B to C, etc. (2)

4.2 Determine the magnitude of each of the four displacements: AB, BC, CD and DE. (4)

4.3 Determine the direction in which the ant travelled during each displacement giving the angle measured in bearings relative to the N-S line passing through A. (4)

4.4 Calculate the total distance (path length) that the ant travelled. (2)

4.5 Determine the resultant displacement of the ant. (4)

5. Direction can be specified in terms of cardinal points, or in terms of bearings.

5.1 Convert these directions specified in terms of cardinal points into bearings.

a) North (N)

b) West (W)

c) North-west (NW)

d) 40° north of east

e) 10° west of north (5)

5.2 Convert these directions specified in terms of bearing to directions specified in terms of the cardinal points.

a) 045°

b) 030°

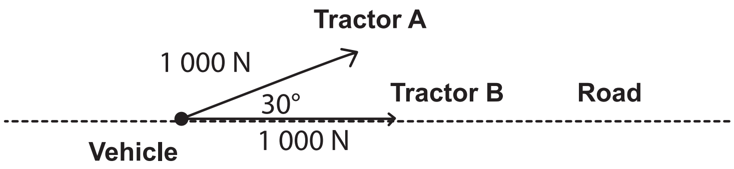
c) –045°

d) 180°

e) 135° (5)

ENRICHMENT:

6. Two tractors pull a vehicle out of the mud. Tractor A pulls with a force of 1 000 N at 30° to the left of the road, and Tractor B pulls with a force of 1 000 N in the direction of the road, as shown in the diagram below.



6.1 Determine the magnitude of the resultant force on the vehicle. (5)

6.2 Determine the angle at which the vehicle moves relative to the road. (2)

CONSOLIDATION EXERCISE

TOTAL: 40 MARKS

1. **1.1** Define "a vector quantity". (2)

1.2 Which of the following quantities are vector quantities?

a) speed

b) friction

c) velocity

d) displacement

e) distance (3)

1.3 Draw a scale vector diagram of 3 N + 4 N with a resultant force of 7 N. (4)

1.4 Explain why 3 N + 4 N does not always mean a resultant force of 7 N. (3)

2. A boy walks from one corner to the opposite corner on a soccer field by first walking 50 m north and then 100 m west.

2.1 Define "displacement". (2)

2.2 Determine the distance that the boy walked. (2)

2.3 Use a scale diagram to determine the boy's displacement. (5)

2.4 Explain how his displacement can be zero even though his distance is not zero. (3)

3. A girl paddles her canoe against the current in a river. The current flows at 0,6 $m \cdot s^{-1}$ downstream, and the girl paddles her canoe at 1,2 $m \cdot s^{-1}$ upstream.

3.1 Draw a scale vector diagram showing the velocity of the current, and the velocity of the canoe. (5)

3.2 Determine the resultant velocity of the canoe. Show your method clearly. (3)

3.3 How far upstream does the canoe move in 5 minutes? (3)

3.4 After 5 minutes the girl turns her canoe around, and paddles downstream at 1,2 $m \cdot s^{-1}$.

3.4.1 Determine the magnitude of the resultant velocity of the canoe while it moves downstream. (2)

3.4.2 How much further does she travel in 5 minutes while paddling downstream? (3)

MARKING GUIDELINES

WORKSHEET

1. **1.1** A vector quantity has magnitude✓ and direction✓, and a scalar quantity only has direction.✓ (3)

1.2 Force has magnitude and direction. ✓ (1)

1.3 a) scalar✓

b) scalar✓

c) scalar✓

d) vector✓

e) scalar✓

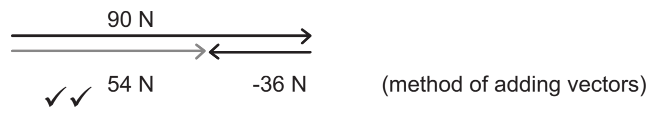
f) vector✓ (6)

2. **2.1** Scale: 1 cm : 20 N ✓ [Learners may use a different scale.

The length of their vectors must represent 90 and 36 N]

(4)

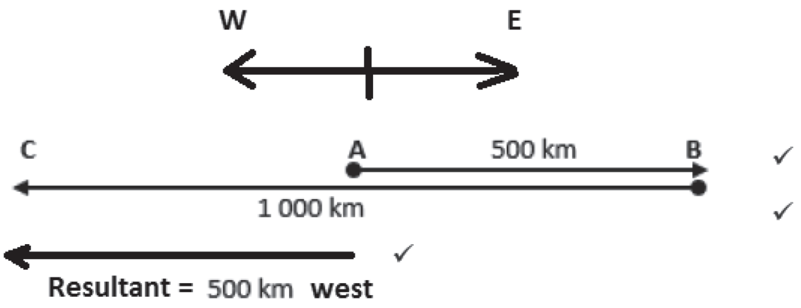
2.2



54 N ✓ forward ✓ (4)

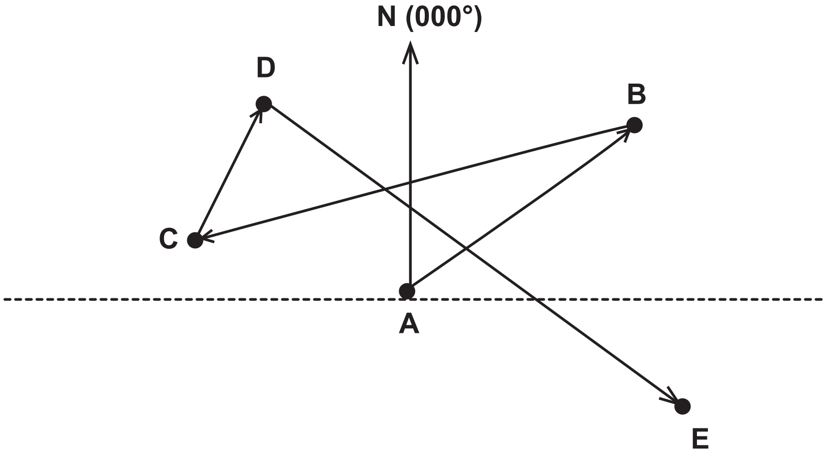
3. **3.1** A vector quantity is a quantity which has magnitude and direction. ✓✓ (2)

3.2 Scale: 1 cm : 200 km ✓ [Learners can use a different scale.]



500 km✓ west of A or on bearing of 180° ✓ (6)

4. Scale: 1 cm : 2 cm



4.1 ✓ arrows joining A to B, B to C, C to D and D to E ✓ with arrows all in the correct direction. (2)

4.2 Measure the length of each arrow (from centre of dot to centre of dot in this case) in cm

Multiply each measurement by 2 (scale 1:2)

Due to typesetting the lengths may vary. The teacher needs to measure these lengths and provide the definitive answer.

As typed in the original document:

AB = 4,25 cm ∴ AB = 8,5 cm✓

BC = 6,82 cm ∴ BC = 13,6 cm✓

CD = 2,44 cm ∴ CD = 4 9 cm✓

DE = 8,00 cm ∴ DE = 16,0 cm✓ (4)

4.3 Pay attention to the direction of the vector relative to the horizontal line through A.

e.g. BC is directed at 15° below the line AB so the angle is 270° – 15° = 255°.

AB = 53°✓

BC = 255°✓

CD = 27°✓

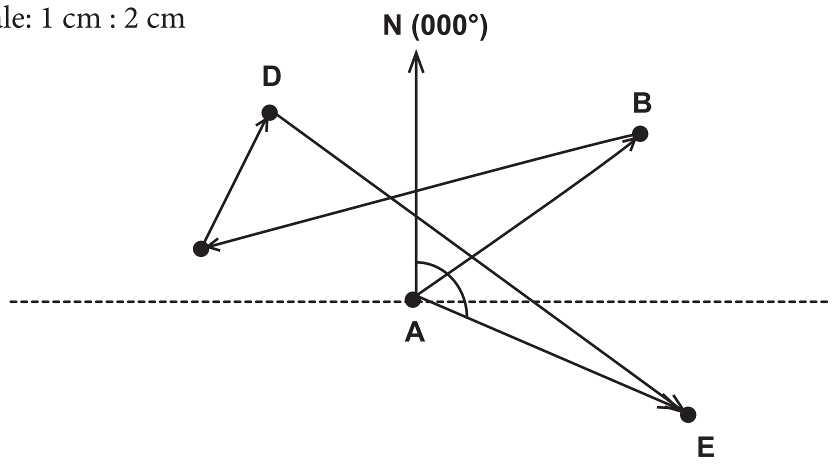
DE = 126°✓ (4)

4.4 Distance = 8,5 + 13,6 + 4,9 + 16,0 (method, c.o.e from 4.2)✓

= 43,0 cm✓ (accuracy; SI units) (2)

4.5 9,2 cm✓ @ 112° ✓

Scale: 1 cm : 2 cm



(4)

5. **5.1** a. 000° ✓

b. 270° ✓

c. 335° ✓

d. 050° ✓

e. 350° OR –010° ✓ (5)

5.2 a. NE OR 45° east of north (or north of east) ✓

b. 30° east of north OR 60° north of east✓

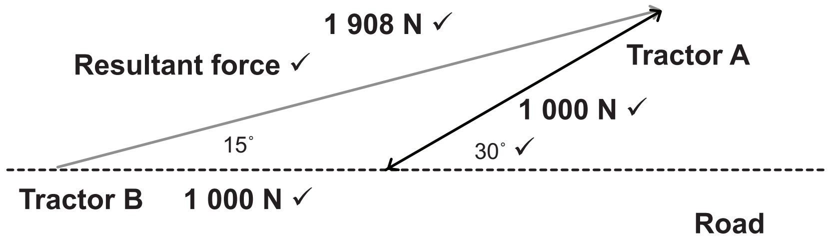
c. NW OR 45° west of north (or north of west) ✓

d. S ✓

e. SE OR 45° east of south (or south of east) ✓ (5)

ENRICHMENT

6. **6.1** Draw a scale diagram placing vectors tail to head e.g. as in the example below.



6.2 Measure the angle using a protractor:

15 ✓ °✓ (2)

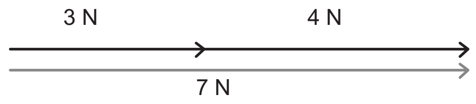
CONSOLIDATION EXERCISE

TOTAL: 40 MARKS

1. **1.1** A vector quantity is a physical quantity that has magnitude and direction.✓✓ (2)

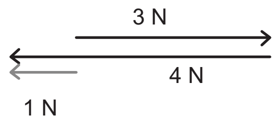
1.2 b. friction✓ c. velocity✓ d. displacement✓ (3)

1.3 Scale: 1 cm : 1 N✓ [Learners can use a different scale]



(4)

1.4 If they act in the opposite direction ✓the resultant force is 1 N.✓

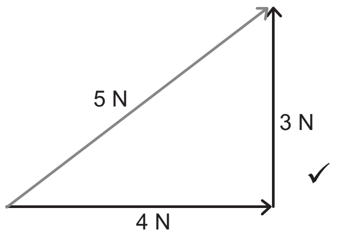


(3)

OR

If the vectors are not acting in the same direction,✓ the resultant force will not be 7 N.✓

e.g.



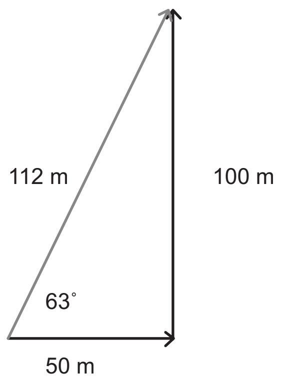
2. A boy walks from one corner to the opposite corner on a soccer field by first walking 50 m north and then 100 m west.

2.1 Displacement is change in position.✓✓ (2)

2.2 Distance = 50 + 100✓ (method)

= 150 m✓ (accuracy; SI units) (2)

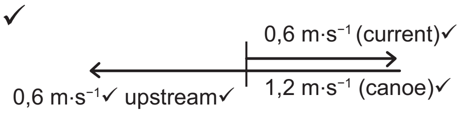
2.3* Scale: 1 cm : 20 m✓



Answer: 112 m at 63° to 50 m displacement.✓ (5)

2.4 If the boy returns to his original position ✓ his displacement is zero. ✓ He could have walked away from his original position during this time, so his distance (path length) will not be zero. ✓ (3)

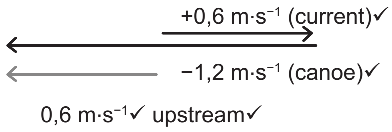
3. **3.1** Scale: 1 cm : 0,25 $m{\cdot}s^{-1}$✓



(5)

3.2 Alternative 1

Scale: 1 cm : 0,25 $m{\cdot}s^{-1}$



Alternative 2

Resultant velocity = 1,2 (upstream) + 0,6 (downstream)

= 1,2 − 0,6 ✓

= 0,6 $m{\cdot}s^{-1}$ ✓ upstream ✓ (3)

3.3 Distance = speed × time ✓ (method)

= 0,6 × (5 × 60) ✓ (converting minutes to seconds)

= 180 m ✓ (accuracy; SI units) (3)

3.4 **3.4.1** Resultant velocity = 1,2 + 0,6 ✓ (method OR graphical method)

= 1,8 $m{\cdot}s^{-1}$ ✓ (accuracy; SI units) (2)

3.4.2 Distance = speed × time

= 1,8 × (5 × 60) ✓ (substitutions; c.o.e)

= 540 m ✓ (accuracy; SI units)

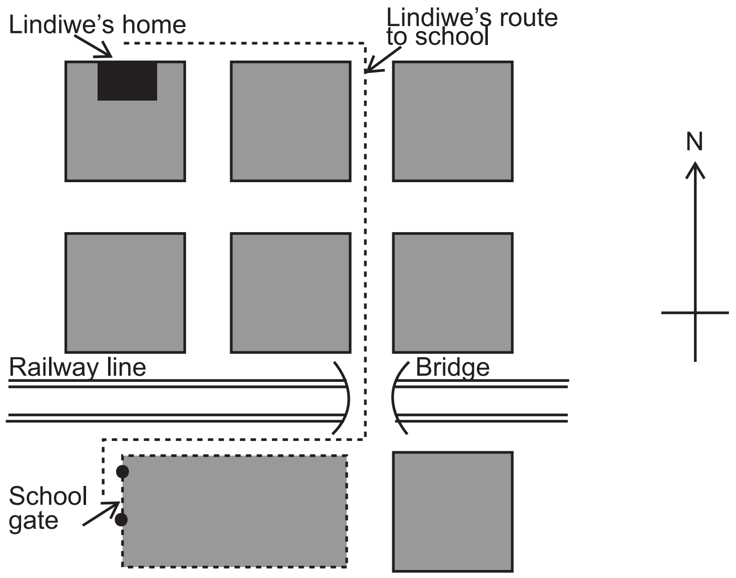
Extra distance = 540 − 180

= 360 m ✓ (accuracy; SI units) (3)

Topic 20: 1-D motion, Speed, Velocity and Acceleration

WORKSHEET

1. Lindiwe walks to school every morning as shown in the diagram below.



1 cm on the diagram represents 20 m.

1.1 Clearly distinguish between distance and displacement. (3)

1.2 Determine the distance that Lindiwe walks every morning from home to the school gates. (3)

1.3 What is her displacement at the school gate? (3)

1.4 What is her displacement when she gets home? (1)

2. Determine the distance and displacement of each of the following journeys. If necessary use a scale diagram to help you work out the displacement and/or distance.

2.1 Cindy walks 700 m in a straight line on a bearing of 210°. (3)

2.2* Simphiwe walks 50 m due north then turns around and walks 150 m due south. (3)

2.3 James runs four times round a circular athletics track with a circumference of 440 m and stops when he gets to the starting line again. (3)

3. Determine the average speed and the average velocity of each of the following journeys (in $m \cdot s^{-1}$).

3.1 Lerato walks for 35 minutes for 2,5 km along the road from home to school. The school is located 1 km south east from her home. (5)

3.2 It takes Thomas 4 minutes to run around a rectangular sports field with length of 200 m and width of 100 m, and return to his starting position. (5)

4. If you drive your car at an average speed of 105 $km \cdot h^{-1}$, how far (in km) will you go in 3 hours 30 minutes? (4)

5. A bullet travels at 800 $m \cdot s^{-1}$. How long will it take for the bullet to travel 1 km? (4)

6. Charles rides his bicycle 7 km north at an average speed of 21 $km \cdot h^{-1}$. He stops for lunch for 20 minutes, then rides 5 km south for 15 minutes.

6.1 Calculate how long (in minutes) it took Charles to ride the 7 km. (4)

6.2 Calculate his average speed (in $km \cdot h^{-1}$) for the whole journey. (4)

6.3 Calculate his displacement (in km) at the end of the journey. (4)

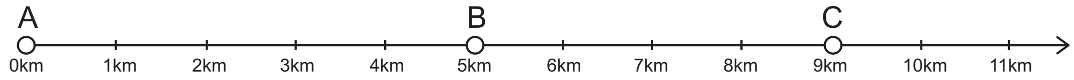
6.4 Calculate his average velocity (in km) for the whole journey. (4)

7. You drive your car for 2 hours at an average speed of 45 $km \cdot h^{-1}$, then for 2 hours at an average speed of 80 $km \cdot h^{-1}$. What is the average speed for the whole journey? (5)

CONSOLIDATION EXERCISE

TOTAL: 48 MARKS

1. An object moves from point A to point B to point C, then back to point B and then to point C in 20 minutes, travelling along the line shown in the diagram below.



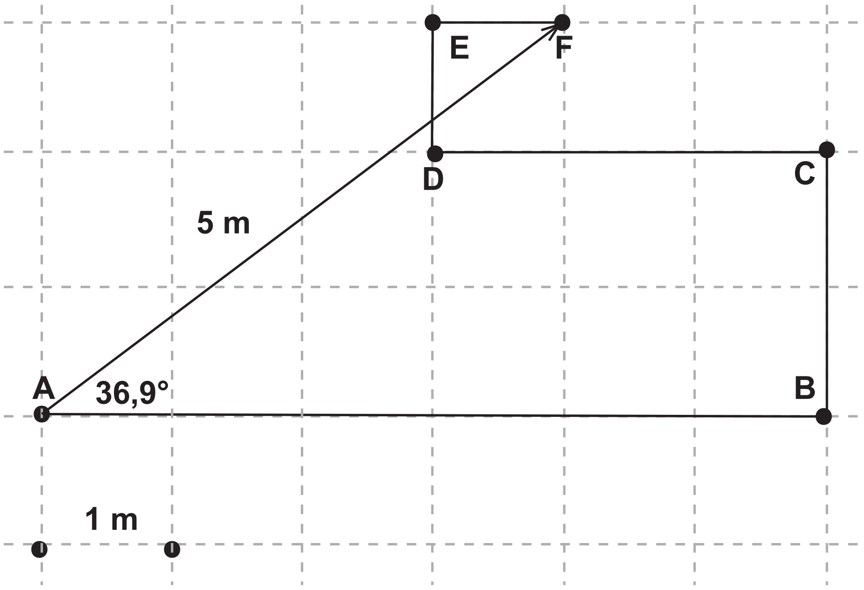
1.1. Calculate the total distance moved by the object in 20 minutes. (2)

1.2. Calculate the displacement of the object in 20 minutes. (3)

1.3. Calculate the average speed of the object in 20 minutes, in $km{\cdot}h^{-1}$. (3)

1.4. Calculate the average velocity of the object in 20 minutes, in $km{\cdot}h^{-1}$. (4)

2. An object moves from A to B to C to D to E to F in 30 seconds, as shown in the diagram below.



2.1. Calculate the distance moved in 30 s. (2)

2.2. The vector drawn from A to F shows the object's displacement in 30 s. With reference to the definition of displacement, explain why this vector gives the object's displacement, and write down the magnitude and direction of its displacement. (4)

2.3. Calculate the average speed of the object in 30 s. (3)

2.4 Calculate the magnitude of its average velocity in 30 s. (3)

3. A rocket accelerates upwards from rest to 270 $m \cdot s^{-1}$ in 10 s reaching a height of 1,35 km above its original position.

3.1 Calculate the acceleration of the rocket. (5)

3.2 Calculate the average speed of the rocket during these 10 s. (3)

3.3 The rocket continues to rise at its maximum speed for another 10 s. How high is it above its original position after 20 s? (4)

4. A car slows down from 36 $km \cdot h^{-1}$ to stop in 25 s.

4.1 Define "acceleration". (2)

4.2 Convert 36 $km \cdot h^{-1}$ to $m \cdot s^{-1}$. (3)

4.3 Calculate the acceleration of the car during these 25 s. (4)

4.4 Does a negative acceleration always imply that an object is slowing down? Briefly justify your answer. (3)

MARKING GUIDELINES

WORKSHEET

1. **1.1.** Distance is the total path travelled.✓ Displacement is the change in position.✓ Distance is a scalar quantity whereas displacement is a vector quantity. ✓ (3)

1.2. Lindwe's distance:

From the map: Distance = 3,3 + 5,3 + 3,3 + 0,8 ✓ (accuracy)

= 12,4✓ cm (method: adding cm)

Converting to Distance walked = 12,4 × 20 = 248 m ✓ (conversion; SI units) (3)

1.3. Displacement = 6,7 × 20✓ (method)

= 134 m ✓ South ✓ (conversion)

(direction) (3)

1.4. 0 m (zero) ✓ (1)

[There is no change in position when she gets back to her starting point.]

2. **2.1.** Cindy: Distance = 700 m ✓ (accuracy; SI units)

Displacement = 700 m ✓on a bearing of 210°✓ (accuracy; SI units)

(direction) (3)

2.2. Simphiwe: Distance = 50 + 150 = 200 m (accuracy; SI units)

Displacement = 50 – 150 ✓ (method)

= – 100

= 100 m ✓ south✓ (accuracy; SI units; direction) (3)

2.3. James: Distance = 4 × 440 ✓ (method)

= 1 760 m ✓ (accuracy; SI units)

Displacement = 0 m✓ (3)

3. **3.1.** Distance = 2 500 m Time: 35 × 60 = 2 100 s✓ (conversions)

$$\text{Average speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{2\,500}{2\,100}$$ ✓ (substitutions)

$= 1{,}19\ m{\cdot}s^{-1}$ ✓ (accuracy; SI units)

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{1\,000}{2\,100}$$ ✓ (substitutions)

$= 0{,}48\ m{\cdot}s^{-1}$ ✓south east ✓ (accuracy; SI units)

(direction) (5)

3.2. Thomas: Distance $= 200 + 100 + 200 + 100 = 600$ m ✓ (method)

Time $= 4 \times 60 = 240$ s ✓ (conversion)

Average speed $= \frac{\text{distance}}{\text{time}}$

$= \frac{600}{240}$ ✓ (substitutions)

$= 2{,}5\ \text{m·s}^{-1}$ ✓ (accuracy; SI units)

Displacement $= 0$ m

Average velocity $= 0\ \text{m·s}^{-1}$ ✓ (5)

4. Time = 3 hours 30 minutes = 3,5 hours ✓ (conversion)

Distance = average speed × time ✓ (method)

$= 105 \times 3{,}5$ ✓ (substitutions)

$= 367{,}5$ km ✓ (accuracy; SI units) (4)

5. Distance = 1 km = 1 000 km ✓ (conversion)

Time $= \frac{\text{distance}}{\text{average speed}}$ ✓ (method)

$= \frac{1000}{800}$ ✓ (substitutions)

$= 1{,}25$ s ✓ (accuracy; SI units) (4)

6. 6.1. Time $= \frac{\text{distance}}{\text{average speed}}$ ✓ (method)

$= \frac{7}{21}$ ✓ (substitutions)

$= 0{,}33 \times 60$✓ (conversion hours to minutes)

$=$ 20 minutes ✓ (accuracy; SI units) (4)

6.2. Total distance $= 7 + 5 = 12$ km

Total time $= 20 + 20 + 15$✓ (accuracy)

$= \frac{55}{60}$ hours ✓ (conversion minutes to hours)

Average speed $= \frac{\text{distance}}{\text{time}}$

$= \frac{12}{\left(\frac{55}{60}\right)}$ ✓ (substitutions)

$= 13{,}09\ \text{km·h}^{-1}$ ✓ (accuracy; SI units) (4)

***6.3.** Displacement $= \sqrt{7^2 + 5^2}$ ✓ (method)

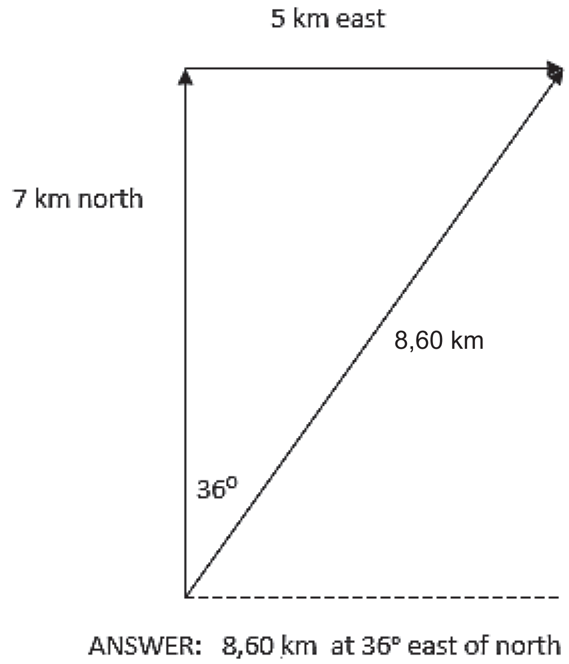
$= 8{,}60$ km ✓ (accuracy)

Direction $= \tan^{-1}\left(\frac{5}{7}\right)$ ✓ (method)

$= 35{,}54°$ east of north (or bearing of $035{,}54°$) ✓ (accuracy) (4)

OR USING A SCALE DIAGRAM:

Scale: 1 cm : 1 km



6.4. Average velocity $= \frac{\text{displacement}}{\text{time}}$

$= \frac{8{,}60}{\left(\frac{55}{60}\right)}$ (substitutions; c.o.e from 6.3)

$= 9{,}38\ \text{km·h}^{-1}$ ✓ (accuracy; SI units)

$35{,}54°$ east of north (or bearing of $035{,}54°$) ✓

(accuracy; c.o.e) (4)

7. Distance in first 2 h $= 45 \times 2 = 90$ km✓

Distance in second 2 h $= 80 \times 2 = 160$ km✓

Average speed $= \frac{\text{distance}}{\text{time}}$

$= \frac{160 + 90}{4}$ ✓ method: adding distances)

(substitutions)

$= 62{,}5\ \text{km·h}^{-1}$ ✓ (accuracy; SI units) (5)

CONSOLIDATION EXERCISE

TOTAL 48 MARKS

1. **1.1.** Distance $= 5 + 4 + 4 + 4$ ✓ (method: adding distances)

$= 17$ km✓ (accuracy; SI units) (2)

1.2. Displacement $= 5 + 4$✓ $+ (-4) + 4$✓ (method)

$= 9$ km ✓ (accuracy; SI units) (3)

1.3 Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{17}{\left(\frac{20}{60}\right)}$ ✓ (substitutions)

$= 51\ \text{km}\cdot\text{h}^{-1}$✓ (accuracy; Si units) (3)

1.4. Average velocity $= \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{9}{\left(\frac{20}{60}\right)}$ ✓ (substitutions)

$= 27\ \text{km}\cdot\text{h}^{-1}$ ✓ forward✓ (accuracy; Si units)

(direction) (4)

2. **2.1.** Distance $= 6 + 2 + 3 + 1 + 1$ ✓ (method)

$= 13$ m ✓ (accuracy; SI units) (2)

***2.2.** Displacement is defined as the change in the position of the object relative to its starting position.✓ The line from A to F give us the change in position (the object's displacement).✓

Magnitude of displacement on the diagram = 5 cm

Angle between AF and the horizontal = 37°

Displacement = 5 m ✓at 37° to the horizontal (AB).✓ (4)

2.3. Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{13}{30}$ ✓ (substitutions)

$= 0{,}43\ \text{m}\cdot\text{s}^{-1}$ ✓ (accuracy; SI units) (3)

2.4. Average velocity $= \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{5}{30}$ ✓✓ (substitutions)

$= 0{,}17\ \text{m}\cdot\text{s}^{-1}$ ✓ (accuracy; SI units) (4)

3. 3.1. $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{270 - 0}{10}$ (substitutions)

= 27 m·s⁻² ✓ upward ✓ (accuracy; SI units) (direction) (4)

3.2. Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{1350}{10}$ ✓ (substitutions)

= 135 m·s⁻¹ ✓ (accuracy; SI units) (3)

3.3. Further distance = speed × time✓ (method)

= 270 × 10✓ (substitutions)

= 2 700 m

Height = 1,350 + 2,700 ✓ (method)

= 4 050 m (or 4,05 km) ✓ (accuracy; SI units) (4)

4. 4.1. Acceleration is the rate of change of velocity. ✓✓ (2)

4.2. 36,36 km.h⁻¹ $= \frac{36,36 \times 1000}{60 \times 60}$ (method)

= 10,1 m·s⁻¹ (accuracy) (2)

4.3. $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{0 - 10,1}{25}$ ✓ (substitutions)

= -0,40 m·s⁻²✓ (accuracy)

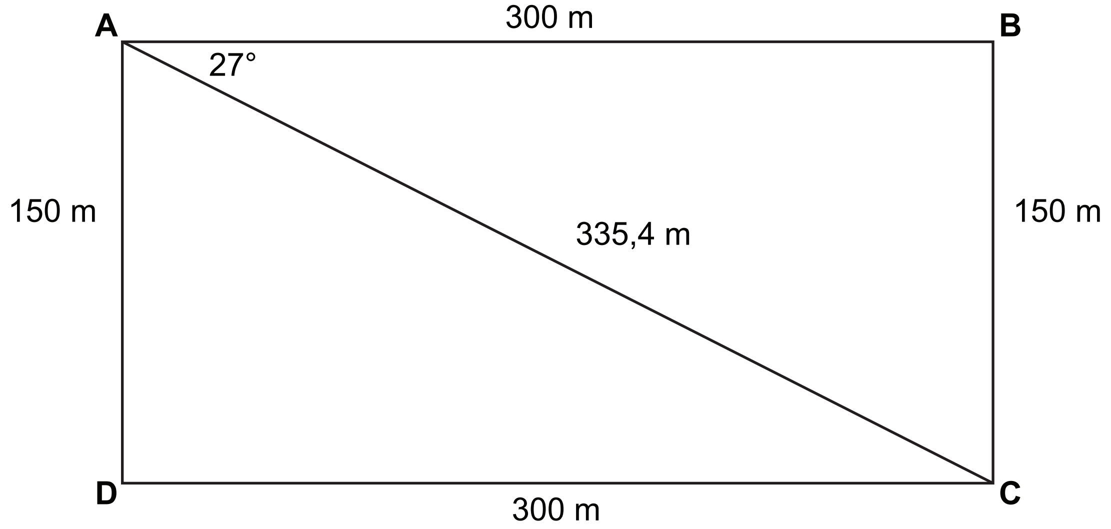
= 0,40 m·s⁻² in the opposite direction✓ (SI units; direction)(4)

4.4. No. If the object stops, (final velocity = 0 m·s⁻¹) ✓ or the velocity is less than the final velocity and still positive, a negative acceleration tells us that the object is slowing down. ✓ In all other cases the object is speeding up in the opposite direction. ✓ (3)

TOPIC 21: INSTANTANEOUS SPEED AND VELOCITY AND EQUATIONS OF MOTION

WORKSHEET

1. A boy takes 10 minutes to run around the perimeter of the school playing fields, as shown in the diagram below. He runs at a steady (constant) speed from A through B, C and D and back to A again.



For the circuit from A through B, C and D, and back to A, ….

1.1 calculate his average speed. (4)

1.2 determine his displacement. (2)

1.3 calculate his average velocity. (2)

For the part of the circuit from A through B to C, …

***1.4** write down his displacement (with reference to the line AB) (2)

***1.5** calculate his average velocity from A to C. (3)

[13]

2. A racing car accelerates uniformly from 0 to 100 $km \cdot h^{-1}$ in 7,5 s.

2.1 Define the term "acceleration". (2)

2.2 Convert 100 $km \cdot h^{-1}$ to $m \cdot s^{-1}$. (2)

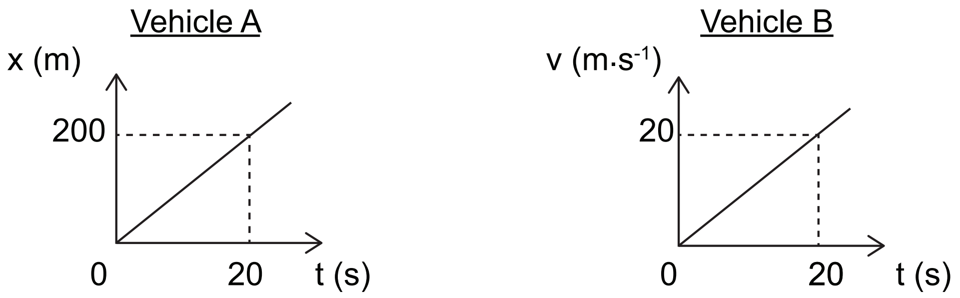
2.3 Calculate the magnitude of the car's acceleration. (3)

2.4 How far does the car travel during this time? Show your calculation. (3)

2.5 The driver applies the brakes and brings the car to a stop from 100 $km \cdot h^{-1}$ in 10 s. Calculate the car's acceleration during these 10 s. (4)

[14]

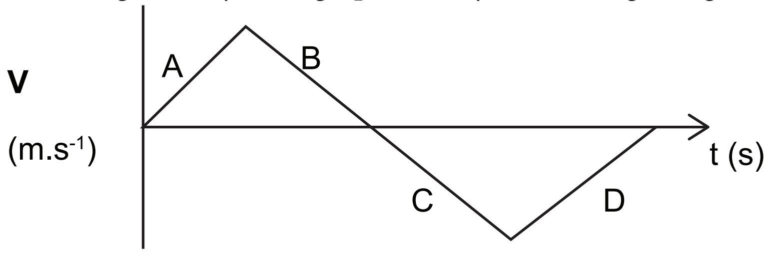
3. The two graphs, shown below, are plotted for two different vehicles (Vehicle A and Vehicle B). Study these two graphs and answer the questions which follow.



3.1 Describe how the motion of Vehicle A differs from that of Vehicle B. (2)

3.2 How do the displacements of the two vehicles differ after 20 seconds? Which vehicle has travelled further? Justify your answer with reference to the graphs. (4)

3.3. Study the following velocity-time graph of a toy car moving along a straight track.



Describe the motion of the car in terms of the magnitude of its velocity, and its direction of travel. Take the positive direction to represent "forward". Copy the table below and write in your answers for each stage of the car's journey.

	VELOCITY IS INCREASING/ DECREASING	DIRECTION OF MOTION IS TOWARDS/ AWAY FROM THE OBSERVER
A		
B		
C		
D		

(8)

[14]

4. A car accelerates uniformly from a stop street along a straight road, covering the following distances in 10 s as shown in the table below.

ELAPSED TIME (*t*) IN SECONDS	2	4	6	8	10
DISTANCE FROM STARTING POSITION (m)	10	18	24	28	30

4.1 Plot a displacement – time graph of the car's motion (on a piece of graph paper). (6)

4.2 **4.2.1** Describe the shape of the graph. (1)

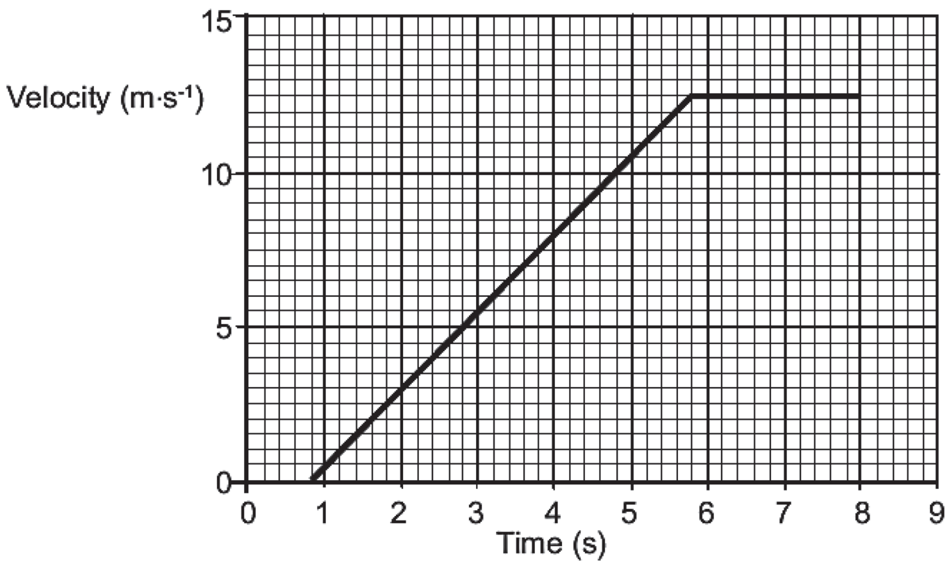
4.2.2 Describe the motion of the car. (2)

4.3 Use the graph to determine the magnitude of the average velocity of the car. (3)

4.4 Use the graph to determine the magnitude of the instantaneous velocity of the car at 3 s. (3)

[15]

5. A driver stops his car at the traffic light when it turns red. The graph of the car's velocity against time shows its motion for 8 s from the time the traffic light turns green.



5.1 The short time interval between the traffic light turning green (for GO) and the driver responding to the signal, is known as "the driver's reaction time".

5.1.1 How long does the driver take to respond when the traffic light changing to green? (1)

5.1.2 Give TWO factors that can affect the reaction time of a driver. (2)

5.2 Determine the maximum speed of the car. (1)

5.3 Use the graph to calculate the average acceleration of the car. (4)

5.4 Use the graph to determine the displacement of the car over these 8 s. (4)

5.5 Calculate the average velocity of the car over 8 s. (3)

[15]

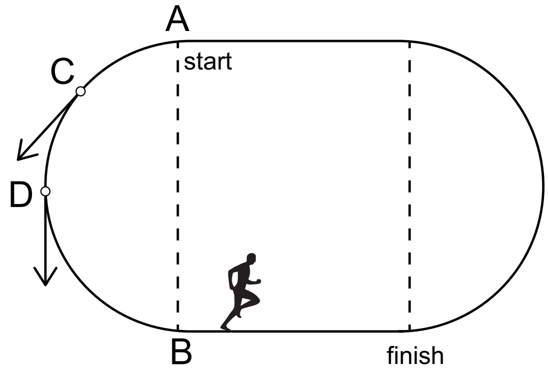
6. A driver speeds through an urban area at 25 $m \cdot s^{-1}$. A traffic cop gives chase as the driver passes her. She accelerates from rest to a maximum speed of 30 $m \cdot s^{-1}$ for 40 s, and then she draws level with the speeding driver *t* seconds later.

   Using this data, determine how long it takes the traffic cop from the moment she gives chase to the time she draws level with the speeding car. [8]

CONSOLIDATION EXERCISE

TOTAL: 63 MARKS

1. An athlete starts his 200 m race on an oval track at A. He completes the first 100 m (marked B) in 11,0 s and eventually finishes the race in a total time of 23,5 s.



1.1 Calculate the average speed of the athlete over the first 100 m of the race. (3)

1.2 Distinguish between instantaneous velocity and average velocity. (2)

1.3 At C and at D the athlete runs at a constant speed of 9,1 $m \cdot s^{-1}$.

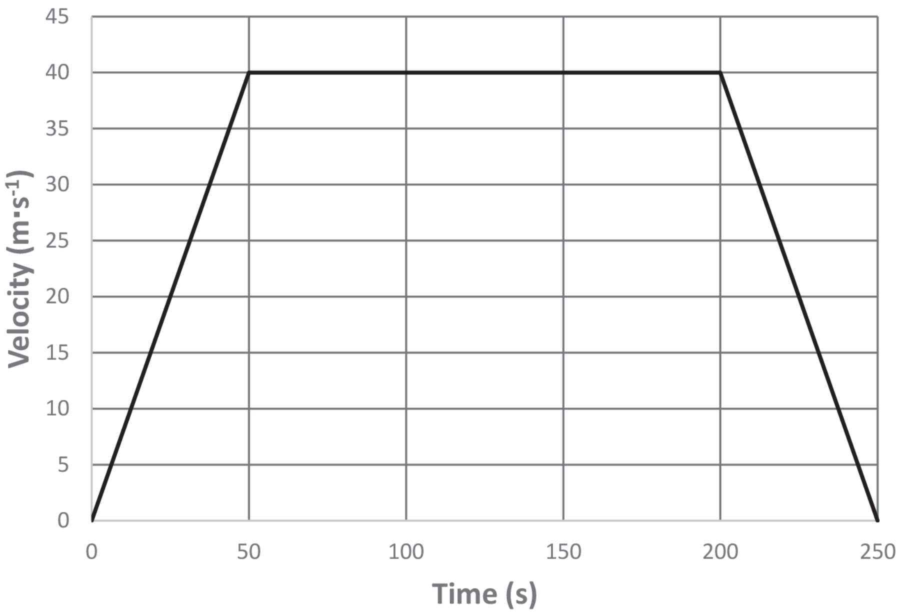
a) What is the magnitude of his instantaneous velocity at C? (1)

b) Explain why his instantaneous velocity at C differs from that at D. (1)

1.4 Calculate his average velocity over the last 100 m of the race. (4)

[11]

2. A graph showing the velocity of a train is plotted against time is shown below.



2.1 What is the maximum speed of the train? (1)

2.2 Describe the motion of the train between points A and B. (1)

2.3 Describe the motion of the train between points B and C. (1)

2.4 How far did the train travel between A and C? (5)

2.5 Determine the acceleration of the train when its brakes were applied. (4)

[12]

3. Ayabonga and Bongi are racing their remote-controlled model cars along a straight flat road. The table below gives details of the two cars' motion.

TIME (s)	AYABONGA CAR'S DISTANCE (m)	BONGI CAR'S DISTANCE (m)
1	4	0,8
2	8	3,2
3	12	7,2
4	16	12,8
5	20	20,0

3.1 On the same piece of graph paper, plot the graphs of Distance against Time for each of the cars. Label each graph with the name of the person whose car it is. (8)

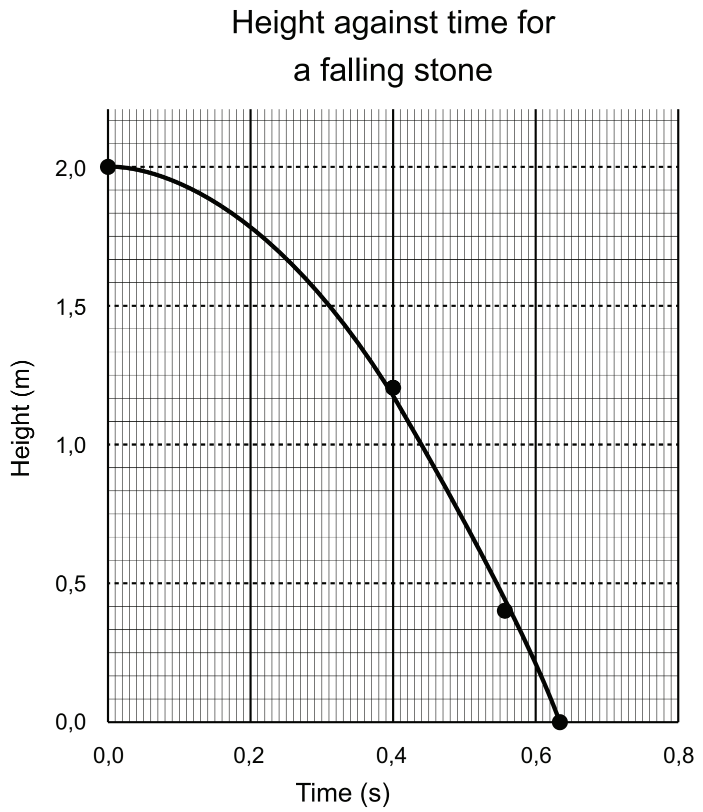
3.2 Describe the motion of Ayabonga's car. (1)

3.3 Describe the motion of Bongi's car. (1)

3.4 Which car, Ayabonga's or Bongi's, will be ahead at 6 s? Show your calculations. (4)

[12]

4. A stone is dropped vertically from a height of 2 m onto the ground. The graph shows the height of the stone above the ground at different times during its fall until it hits the ground after 0,64 s.



4.1 Calculate the average velocity of the stone during its fall of 0,64 s. (4)

4.2 Calculate the average speed of the stone from 0,4 to 0,64 s. (4)

4.3 Explain how the shape of the graph tells us that the stone accelerated uniformly as it fell to the ground. (2)

4.4 Use the values for speed and velocity calculated in **4.1** and **4.2** to determine the magnitude of the acceleration of the stone. NB: The magnitude of the average velocity (or speed) is equal to the instantaneous velocity (or speed) at halfway through the time. (3)

[13]

5. A taxi-driver drives his taxi at 25 $m \cdot s^{-1}$ in an 80 $km \cdot h^{-1}$ traffic zone. He suddenly notices a traffic officer operating a speed trap in the road 24 m ahead of him. He applies brakes and decelerates constantly at 1,8 $m \cdot s^{-2}$.

5.1 Calculate the speed of the taxi when it passes the traffic officer. (4)

5.2 Determine whether the taxi was breaking the speed limit when it passes the traffic officer. Show your calculation. (2)

[6]

6. A cyclist accelerates uniformly from rest on a straight, horizontal road at point A and reaches point Y, covering the last 10 m of his ride in 2 s.

6.1 Calculate the magnitude of his average velocity over the last 2 s. (2)

6.2 What is his instantaneous velocity 1s before reaching point Y? (1)

6.3 Calculate his constant acceleration over this last 1 s if he reaches a velocity of 9 $m \cdot s^{-1}$ at point Y. (4)

[7]

MARKING GUIDELINES

WORKSHEET

1. **1.1** $\text{average speed} = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{300 + 150 + 300 + 150}{10 \times 60}$ (calculating distance)

$= 1,5 \text{ m·s}^{-1}$ (converting minutes to seconds)

(accuracy; SI units) (4)

1.2 Displacement = 0 m ✓✓ (No change in position) (2)

1.3 $\text{average velocity} = \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= 0 \text{ m·s}^{-1}$ ✓ (accuracy; SI units) (2)

1.4 Displacement = 335,4 m ✓ at 27° below the line AB ✓ (2)

1.5 $\text{average velocity} = \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{335,4}{600}$ ✓ (substitutions)

$= 0,56 \text{ m·s}^{-1}$ at 27° ✓ (accuracy; SI units) (3)

[16]

2. **2.1** Acceleration is the rate of change of velocity. ✓✓ (2)

2.2 $100 \text{ km·h}^{-1} = \frac{100 \times 1\,000}{60 \times 60}$ (method)

$= 27,78 \text{ m·s}^{-1}$ ✓ (accuracy; ignore SI units) (2)

2.3 $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{27,78 - 0}{7,5}$ ✓ (substitutions)

$= 3,70 \text{ m·s}^{-2}$ ✓ (accuracy; SI units) (3)

2.4 ALTERNATIVE 1

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓ (method)

$= 0 + \frac{1}{2}(3,7) \times (7,5)^2$ ✓ (substitutions; c.o.e)

$= 104,06 \text{ m}$ ✓ (accuracy; SI units)

ALTERNATIVE 2

$v_f^2 = v_i^2 + 2a\Delta x$ (method)

$(27,78)^2 = 0^2 + 2(3,7)\Delta x$ (substitutions; c.o.e)

$\Delta x = 104,06 \text{ m}$ (accuracy; SI units)

ALTERNATIVE 3

$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$ ✓ (method)

$= \left(\frac{27,78 + 0}{2}\right)(7,5)$ ✓ (substitutions)

= 104,06 m (accuracy; SI units) (3)

2.5 $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{0 - 27,78}{10}$ ✓ (substitutions)

= $-2,78\ \text{m·s}^{-2}$ ✓ (accuracy; SI units)

$2,78\ \text{m·s}^{-2}$ in the opposite direction (backwards) (4)

[14]

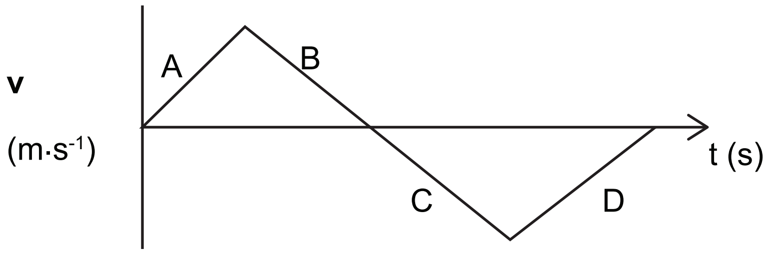
3. **3.1** Vehicle A travels at constant (uniform velocity) ✓ and Vehicle B travels at constant (uniform) acceleration. ✓ (2)

3.2 Vehicle A: After 20 s it has travelled 200 m. ✓

Vehicle B: Displacement = area under the graph✓ = ½ (20)×20 ✓= 200 m

Both have travelled the same distance. ✓ (4)

3.3.



	VELOCITY IS INCREASING/ DECREASING	DIRECTION OF MOTION IS TOWARDS/ AWAY FROM THE OBSERVER
A	Increasing ✓	Away ✓
B	Decreasing ✓	Away ✓
C	Increasing ✓	Towards ✓
D	Decreasing ✓	Towards ✓

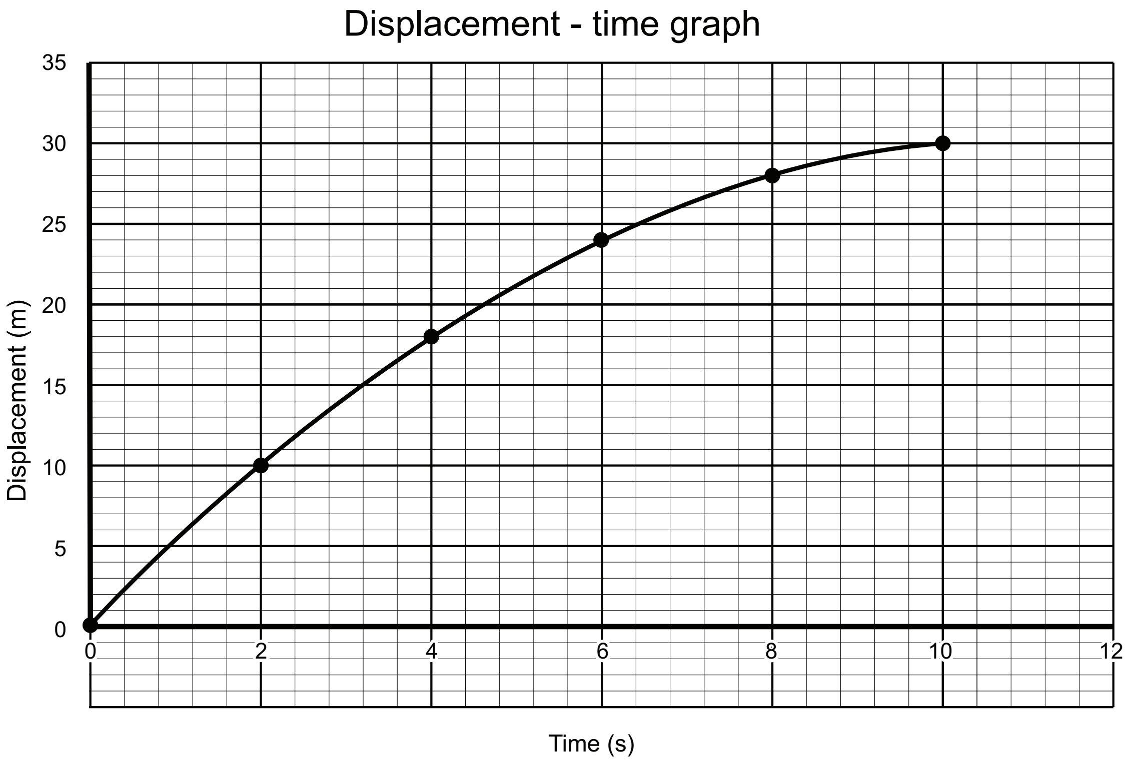
(8)

[14]

4.

Elapsed time (t) in seconds	2	4	6	8	10
Displacement from starting position (m)	10	18	24	28	30

4.1



✓Appropriate title for graph

✓Vertical axis: scale, titles, SI units

✓Horizontal axis: scale, title, SI units – Time must be plotted on the x-axis

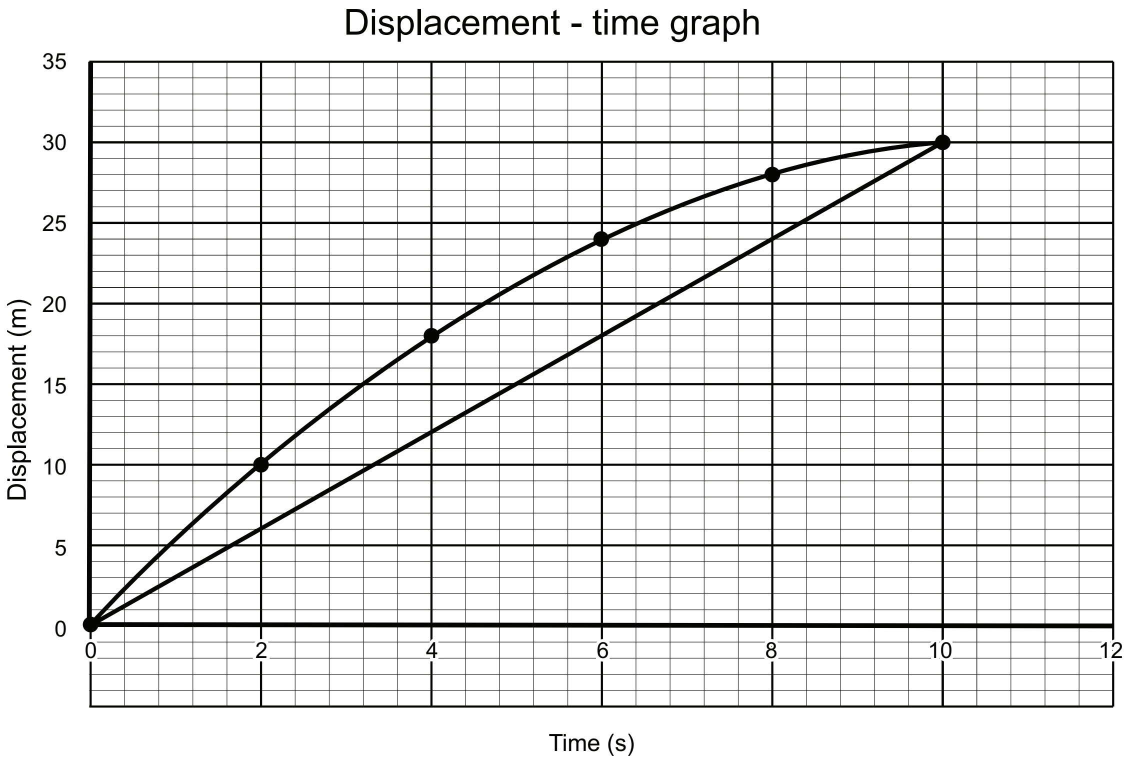
✓Points plotted correctly

✓Smooth line of best fit

✓Line of best fit passes through the origin (6)

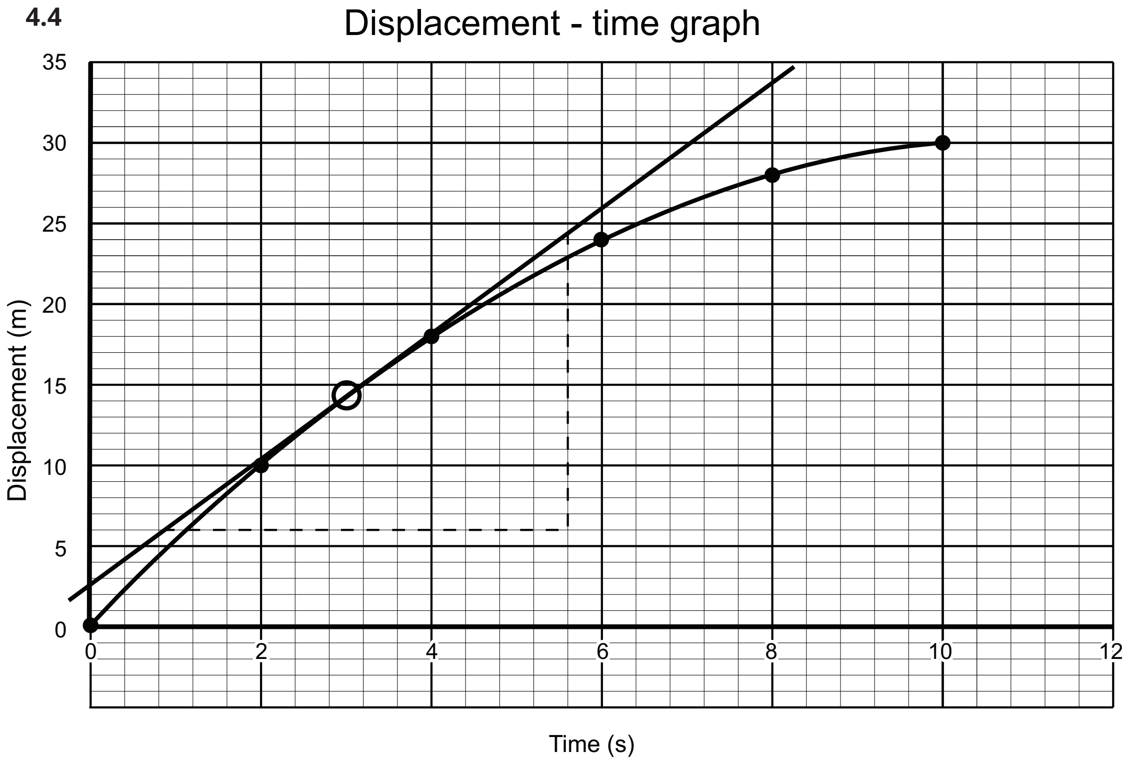
4.2 **4.2.1** A parabola curving downward (a smooth curve with a steadily decreasing slope.) (1)

4.2.2 The car is slowing down at a constant (uniform) rate (OR uniform deceleration OR uniform negative acceleration). (2)



4.3 average velocity = gradient of line shown on graph $= \frac{30-0}{10-0} = 3\ m \cdot s^{-1}$

4.4



Method of taking the gradient at 3,0 s clearly shown on the graph ✓

Gradient $= \frac{29,0-6,0}{6,8-0,8}$ ✓ (as shown on the graph)

$= 3,83\ m \cdot s^{-1}$ ✓ (accuracy; SI units) (3)

[15]

5. **5.1** **5.2.1** 0,8 s✓ (1)

5.2.2 The driver's concentration (due to ill health, older age, being distracted by cell phone message or call, affected by alcohol or medication or taking illegal drugs) ✓

The driver's reflexes (the time taken for his mind to respond to seeing the traffic light go green) (due to ill health, older age, inexperienced driver who has recently passes the driver's test, alcohol or medication or taking illegal drugs). ✓ (2)

5.2 12,5 m·s^{-1} ✓ (accuracy; SI units) (1)

5.3 $a = \frac{\Delta v}{\Delta t}$(gradient of the graph) ✓ (method)

$= \frac{12,5-0}{5,8-0,8}$ ✓✓ (substitutions)

= 2,5 m·s^{-2} ✓ (accuracy; SI units) (4)

5.4 Displacement = area under the graph ✓ (method)

= (½ (5,8 – 0,8) × 12,5)✓ + (12,5 × (8 – 5,8)) ✓ (substitutions)

= 58,75 m✓ (accuracy; SI units) (4)

5.5 average velocity = $\frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{58,75}{8}$ ✓ (substitutions)

= 7,34 m·s^{-1} ✓ (accuracy; SI units) (3)

[15]

6. **Traffic cop**

Distance covered = ½ (0+30) × 40 ✓ + 30*t*✓ (method)

= 600 + 30*t*

Driver of speeding car

Distance covered = 25 × 40 ✓ + 25*t*✓ (method)

= 1 000 + 25*t*

They both covered the same distance during this time.

600 + 30*t* = 1 000 + 25*t*✓ (showing the distances are equal)

5*t* = 400

t = 80 s✓ (solving for t)

Total time = 40 + 80✓ (adding 40 to t)

= 120 s✓ (accuracy; SI units) [8]

CONSOLIDATION EXERCISE

TOTAL: 63 MARKS

1. **1.1** $\text{average speed} = \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{200}{23,5}$ ✓ (substitutions)

$= 8,51\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) (3)

1.2 The instantaneous velocity is the rate of change of position over a very short time interval, ✓ whereas the average velocity is the rate of change of position (displacement) over the total time taken. ✓ (2)

1.3 At C and at D the athlete runs at a constant speed of 9,1 m·s^{-1}.

1.3.1 9,1 m·s^{-1} ✓ (1)

1.3.2 The magnitude of the instantaneous velocity is 9,1 m·s^{-1}, but the direction of the instantaneous velocity differs (as shown by the arrows in the diagram), ✓ (1)

1.4 $\text{average velocity} = \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{100}{(23,5 - 11)}$ ✓ (substitutions)

$= 8,0\,\text{m·s}^{-1}$ ✓ to the right ✓ (accuracy; SI units) (4)

[11]

2. **2.1** 40 m·s^{-1} ✓ (accuracy; SI units) (1)

2.2 Uniform (constant) velocity ✓ (1)

2.3 Uniform✓ (negative) acceleration OR uniform✓ deceleration ✓ (2)

2.4 Distance = area under the graph from 50 s to 250 s ✓ (method)

= (200 – 50) × 40 ✓ + ½ × (250 – 200) × 40 ✓ (substitutions)

= 7 000 m ✓ (accuracy; SI units) (4)

2.5 $a = \frac{\Delta v}{\Delta t}$ (gradient of the graph) ✓ (method)

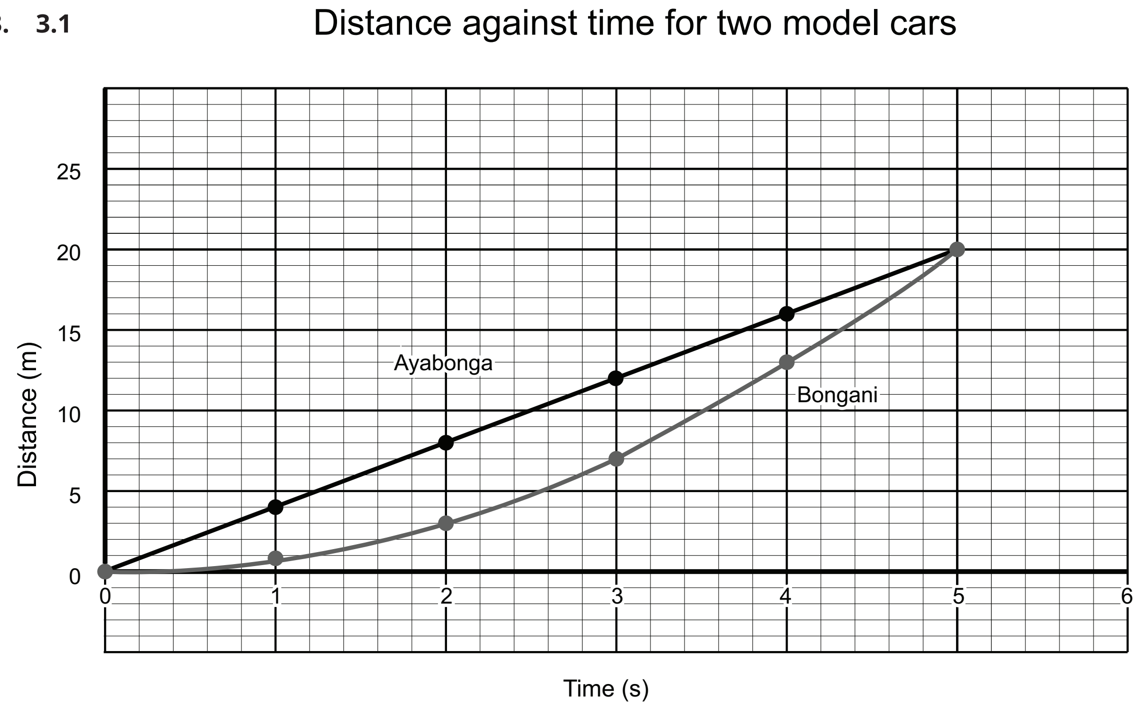
$= \frac{0 - 40}{250 - 200}$ ✓ (substitutions)

= -0,8 m·s^{-2} ✓ (accuracy; SI units)

= 0,8 m·s^{-2} in the opposite direction to its motion ✓ (4)

[12]

3. **3.1**



- ✓ Appropriate title for the graph
- ✓ Choice of axes (Time on the horizontal axis)
- ✓ Scale; axis title; SI units on vertical axis
- ✓ Scale; axis title; SI units on horizontal axis
- ✓ Correct plotting of points (Ayabonga)
- ✓ Correct plotting of points (Bongi)
- ✓ Straight-line graph (Ayabonga)
- ✓ Smooth curve (parabola) (Bongi) (8)

3.2 Ayabonga's car: Uniform (constant) velocity ✓ (1)

3.3 Bongi's car: Uniform acceleration ✓ (1)

3.4 At 6 s, Ayabonga's car will have travelled 24 m ✓ (Either extend the graph OR work out that the distance increases by 4 m every second, therefore it has travelled another 4 m) ✓

Bongi's car is accelerating so if you extend the curve it goes up much further than the graph paper (shown above). ✓Therefore, Bongi's car will have travelled further. ✓

[Possible calculation for Bongi's car]

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$20 = 0 + \frac{1}{2} a (5)^2$$

$$a = 1{,}6 \checkmark \text{m·s}^{-2}$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$= 0 + \frac{1}{2}(1{,}6)(66)^2$$

$$= 28{,}8 \text{ m} \checkmark$$

(4)

[14]

4. **4.1** $\text{average velocity} = \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{2}{0,64}$ ✓ (substitutions)

$= 3,125\,(3,13)\ \text{m·s}^{-1}$ ✓ (accuracy; SI units)

downwards✓ (direction) (4)

4.2 $\text{average speed} = \frac{\text{dis tan ce}}{\text{time}}$ ✓ (method)

$= \frac{1,2}{(0,64-0,40)}$ (substitutions)

$= 5,0\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) (4)

4.3 The graph is shaped as parabola ✓ with the slope of the graph increasing with time ✓ (2)

4.4 At $\frac{1}{2} \times 0,64\ \text{s} = 32\ \text{s}$: $v_i = 3,13\ \text{m·s}^{-1}$ ✓ (accuracy; c.o.e)

At $0,40 + \frac{1}{2}(0,64-0,40) = 0,52\ \text{s}$: $v_f = 5,0\ \text{m·s}^{-1}$

$a = \frac{\Delta v}{\Delta t}$

$= \frac{5,00-3,13}{0,52-0,32}$ ✓ (substitutions; c.o.e)

$= 9,38\ \text{m·s}^{-2}$ ✓ (accuracy; c.o.e) (3)

[13]

5. **5.1** $v_f^2 = v_i^2 + 2a\Delta x =$ ✓ (method)

= (25)2 ✓+ 2 (-1,8)(24) ✓ (substitutions)

= 538,60

$v_f = \sqrt{538,60}$ = 23,21 m·s^{-1}✓ (accuracy; SI units) (4)

5.2 23,21 m·s^{-1} = $\frac{23,21 \times 60 \times 60}{1\,000}$ ✓= 83,56 km.h^{-1} (method)

Yes. ✓

OR 80 km.h^{-1} = $\frac{80 \times 1\,000}{60 \times 60}$ = ✓= 22,22 m·s^{-1} (method)

Yes. ✓ (2)

[6]

6. **6.1** $\text{average velocity} = \frac{\text{displacement}}{\text{time}}$

$= \frac{10}{2}$ ✓ (substitutions)

= 5 m·s^{-1} ✓ (accuracy; SI units) (2)

6.2 5 m·s^{-1} forward✓ (1)

6.3 In the last 1 s of his ride, his speed increases from 5 m·s^{-1} to 9 m·s^{1}.

$a = \frac{\Delta v}{\Delta t}$ ✓ $= \frac{9-5}{1}$ ✓ (substitutions; c.o.e.)

= 4,0 m·s^{-2} ✓ forward ✓ (accuracy; SI units) (direction) (4)

FORMAL EXPERIMENT

FORMAL EXPERIMENT

GRADE 10 TERM 3: PHYSICS

Measuring Acceleration

56 Marks

This section provides guidance and assessment of the learner's knowledge and understanding when carrying out a virtual experiment using the NECT video of the same name.

If your class is carrying out the experiment using laboratory apparatus and taking down their own results, you must set up your classroom appropriately and give the learners the relevant instructions. You may find it useful to refer to the Technical Instructions which precede the Learner's Instructions while preparing for this experiment.

If the learners are proceeding with the virtual experiment, then continue with the NECT programme by using the information, handouts and marking guidelines contained in this section of this Resource Book.

Formal Experiment

TECHNICAL INSTRUCTIONS

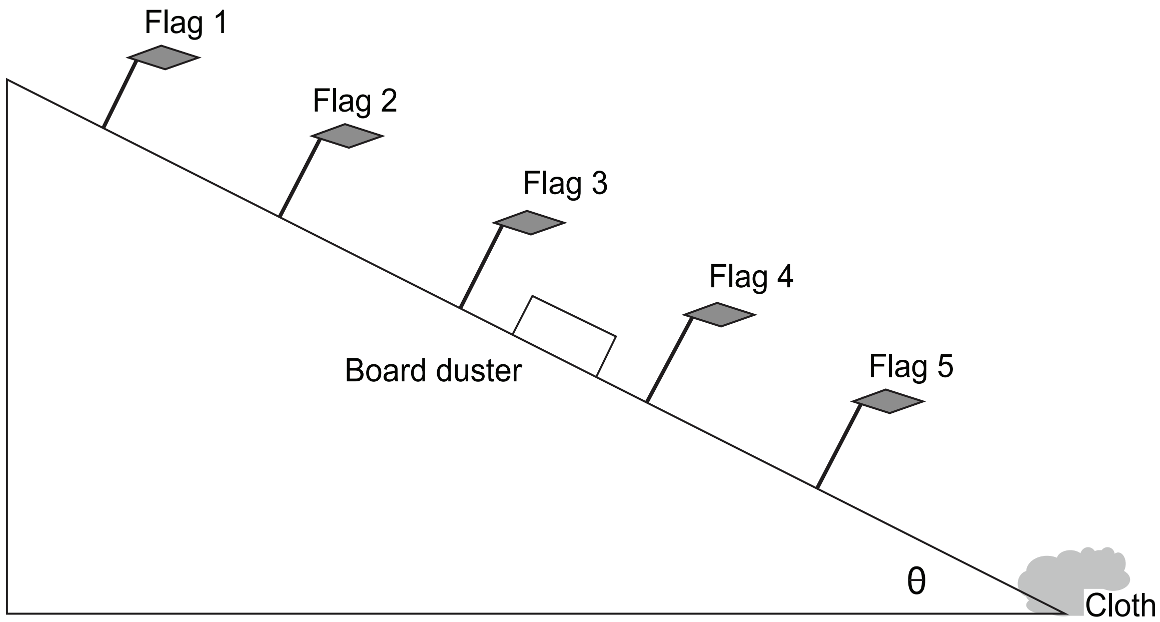
AIM: TO MEASURE THE ACCELERATION OF A BLOCK SLIDING ON AN INCLINED PLANE.

INVESTIGATIVE QUESTION:

How is the acceleration of a block sliding on an inclined plane affected by the sliding surface of the block?

APPARATUS:

Smooth track (about 2 m long if possible)
Chalkboard duster
Prestik or double-sided sellotape
A pile of books (or bricks or other means) to raise the track to various angles of inclination.
Stopwatch
2 m tape measure
5 toothpicks
Coloured paper or material to attach to the toothpicks (to make little flags)
Soft cloth



This equipment is quite tricky to set up.
The learners may require assistance with it.

METHOD:

Setting up the apparatus

1. Set up the track by raising one end of it with a pile of books. Make sure that the track is stable and it rests firmly on the items that support it.
2. Place the board duster at the top of the track with the smooth (wooden) surface in contact with the track.
3. Fold the soft cloth and place it at the end of the track to act as a stopper for the board duster when it reaches the bottom of the track.
4. Carry out a practice run, timing the motion of the duster for the entire length of the track. If the time is less than 4 s, lower the track slightly so that the board duster runs a little slower on the track.
5. Now turn the board duster over with its rough (felt) surface in contact with the track. Carry out a practice run timing its motion down the track. If it seems to move at constant velocity raise the track slightly to make the board duster accelerate.
6. Place the board duster at the top of the track and make a pencil mark on the track at the front of the duster to mark this position. Place a highly visible marker at this position on the track e.g. a toothpick with a piece of coloured paper attached to it as a little flag.
7. Make 4 more pencil marks on the track at 40 cm intervals. Place little flags at each of these marks alongside the track.
8. It is important that the duster does not move too fast on its way down the track else you will struggle to time it accurately. Adjust the height of the track until you can comfortably time its run for each section, and then record the results.

Taking measurements:

1. The first time you will record the total time from start (Flag 1) to finish (Flag 5).
2. The second time you will time from three-quarters of the way down (Flag 2 to Flag 5).
3. Then the third time you will stop timing from half way down the track (Flag 3 to Flag 5).
4. Repeat these measurements (Steps 1 to 3) three times to improve the reliability of your results.
5. When you have completed recording the times for the duster with its rough (felt) surface down, turn the duster over so it now rests its smooth (wooden) suface.
6. Repeat the measurements (from step 1 to 4) with the track at the same inclined angle, but this time the smooth (wooden) surface of the board duster is in contact with the track surface.

NAME: ____

______________________ GRADE: ______________________

Formal Experiment

MEASURING ACCELERATION

56 MARKS

AIM: TO MEASURE THE ACCELERATION OF A BLOCK SLIDING ON AN INCLINED PLANE.

Investigative question:

How is the acceleration of a block sliding on an inclined plane affected by the sliding surface of the block?

Apparatus:

Smooth track (about 2 m long if possible)
Chalkboard duster
Prestik or double-sided sellotape
A pile of books (or bricks or other means) to raise the track to various angles of inclination.
Stopwatch
2 m tape measure
5 toothpicks
Coloured paper or material to attach to the toothpicks (to make little flags)
Soft cloth

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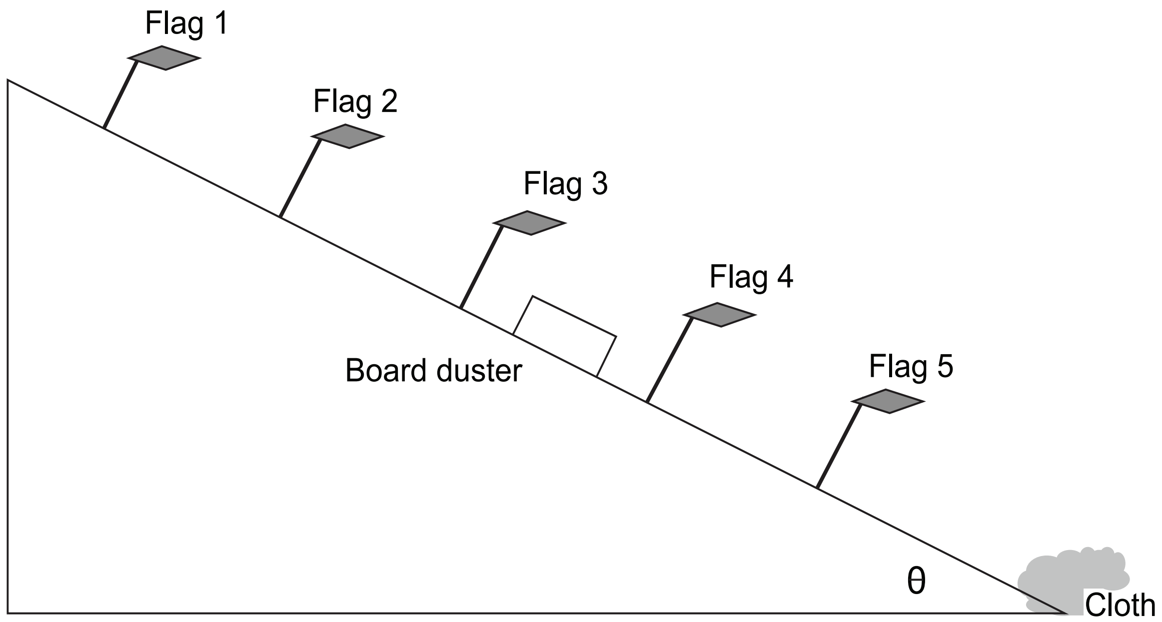


METHOD:

Setting up the apparatus

1. Set up the track by raising one end of it with a pile of books or boxes. Make sure that the track is stable and it rests firmly on the items that support it.
2. Place the board duster at the top of the track with the smooth (wooden) surface in contact with the track.
3. Carry out a practice run, timing the motion of the duster for the entire length of the track. If the time is less than 2 s, lower the track slightly so that the duster runs a little slower on the track.
4. Now turn the duster over with its rough (felt) surface in contact with the track. Carry out a practice run timing its motion down the track. If the duster seems to move at constant velocity raise the track slightly to make the duster accelerate.
5. Place the duster at the top of the track and make a pencil mark on the track at the front of the duster so that it always starts exactly at this position. Place a highly visible marker at this position on the track e.g. a toothpick with a piece of coloured paper attached to it as a little flag.
6. Make 4 more pencil marks on the track at 40 cm intervals. Place little flags at each of these marks alongside the track.
7. It is important that the duster does not move too fast on its way down the track else you will struggle to time it accurately. Adjust the height of the track until you can comfortably time its run for each section, and then record the results.

   NB In the video we used the time recorded by the movie camera to time the run of the duster down the track.

Taking measurements:

1. The first time you will record the total time from start (Flag 1) to finish (Flag 5).
2. The second time you will time from three-quarters of the way down (Flag 2 to Flag 5).
3. Then the third time you will time from half way down the track (Flag 3 to Flag 5).
4. Repeat these measurements (Steps 1 to 3) three times to improve the reliability of your results.
5. When you have completed recording the times for the duster with its rough side down, turn the duster over so it now rests on its smooth (wooden) surface.
6. Repeat the measurements (from step 1 to 4) with the track at the same inclined angle, but this time the smooth (wooden) surface of the board duster is in contact with the track surface.

EXPERIMENT

RESULTS:

Theory

The board duster accelerates uniformly down the track. We measure the distance travelled and the time taken. The duster starts from an initial velocity of zero.

$$\Delta x = v_i t + \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = \frac{1}{2} a \Delta t^2$$

We plot a graph of Δx against $(\Delta t)^2$ to determine the acceleration.

Questions

1. Fill in a title for this table.

Watch the video and record the readings.

Table of results: ______________________________ (1)

Surface of board duster	Calculations	Time (s) (160 cm)	Time (s) (120 cm)	Time (s) (80 cm)
Smooth (wooden side)				
	Average Time (Δt)			
	$(\text{Time})^2 = (\Delta t)^2$			
Rough (felt side)				
	Average Time (Δt)			
	$(\text{Time})^2 = (\Delta t)^2$			

(20)

2. On the same piece of graph paper, plot a graph of Distance against the Square of Time. Place the square of time (Δt^2) on the x-axis, and distance on the y-axis. Draw the best fit line for each graph, and label the graphs as Rough and Smooth. (11)

3. Describe the shape of the graphs. (2)

4. Describe (in words) the relationship between the distance and $time^2$ as the duster accelerated down the slope,

a. with its rough surface in contact with the track. (2)

b. with its smooth surface in contact with the track. (2)

5. Calculate the gradient of the distance - $time^2$ graph

a. with its rough surface in contact with the track. (4)

b. with its smooth surface in contact with the track. (4)

6. What quantity does the gradient of the distance – $time^2$ graph represent? Briefly justify your answer. (4)

7. Calculate and compare the acceleration of the duster when it slides on its two different surfaces (rough and smooth). (2)

8. Explain why the duster accelerates at different rates when different surfaces are in contact with the track. (2)

Conclusion (2)

MARKING GUIDELINES

56 MARKS

AIM: TO MEASURE THE ACCELERATION OF A BLOCK SLIDING ON AN INCLINED PLANE.

Investigative question:

How is the acceleration of a block sliding on an inclined plane affected by the sliding surface of the block?

Theory

The board duster accelerates uniformly down the track. We measure the distance travelled and the time taken. The duster starts from an initial velocity of zero.

We plot a graph of Distance (Δx) against the Square of time (Δt^2) against to determine the acceleration.

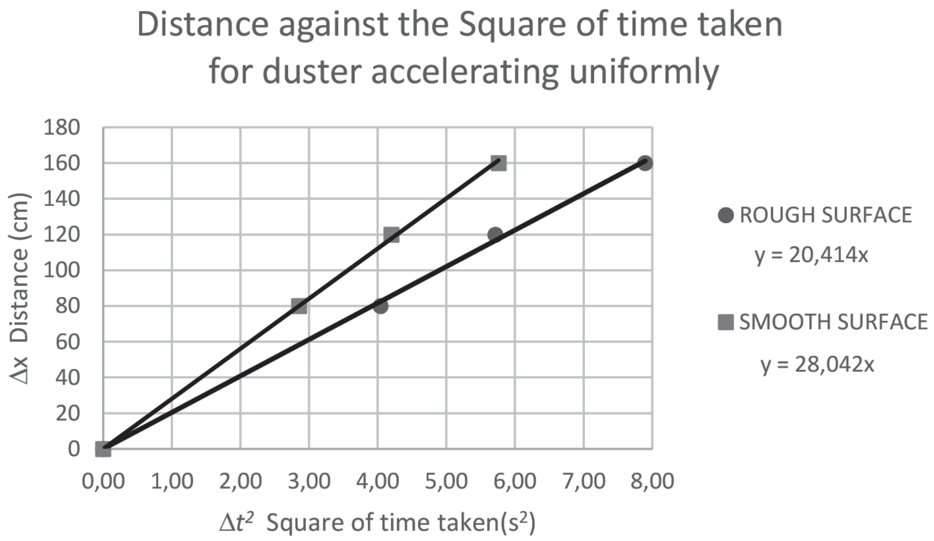
QUESTIONS

1. Table of results: Time taken for board duster to accelerate down track✓ (1)

SURFACE OF BOARD DUSTER	CALCULATIONS	TIME (S) (160 CM)	TIME (S) (120 CM)	TIME (S) (80 CM)
Smooth		2,33✓ 2,45 2,42	2,01 ✓ 2,04 2,09	1,69 ✓ 1,69 1,69
	Average Time (Δt) s ✓	2,40✓	2,05✓	1,69✓
	(Time)^2 = (Δt)^2 s^2 ✓	5,76✓	4,20✓	2,86✓
Rough		2,84✓ 2,79 2,80	2,40✓ 2,42 2,36	2,03✓ 2,00 1,99
	Average Time (Δt) s	2,81✓	2,39✓	2,01✓
	(Time)^2 = (Δt)^2 s^2	7,90✓	5,71✓	4,04✓

(20)

2. On the same piece of graph paper, plot a graph of Distance against the Square of Time. Place the square of time (Δt^2) on the x-axis, and distance on the y-axis. Draw the best fit line for each graph, and label the graphs as Rough and Smooth.



Marking the graph: (11)

- ✓ Appropriate title (heading) e.g. Time2 vs Distance graphs for duster sliding on the track.
- ✓ Correct choice of axes: Distance on x-axis.
- ✓ Appropriate scale on x-axis with label and SI units.
- ✓ Appropriate scale on y-axis with label and SI units.
- ✓ Points plotted correctly (rough).
- ✓ Points plotted correctly (smooth).
- ✓ Rough and smooth graphs labelled (correctly).
- ✓ ✓Best fit straight-line graphs drawn with a ruler.
- ✓ ✓Graphs extended back to cut the y-axis (Must be the same straight-line as the graph).

[NB: It is unnecessary to write the equation on the graph. It appears in the legend on this graph just for the teacher's information.]

3. Describe the shape of the graphs.

Straight-line graph ✓ passing through the origin. ✓ (2)

4. Describe (in words) the relationship between the square of time and distance as the board duster accelerated down the slope

a. with its rough surface in contact with the track.
The square of time taken is directly proportional to the distance (displacement).✓✓

(2)

b. with its smooth cardboard surface in contact with the track.
The square of time taken is directly proportional to the distance (displacement).✓✓

(2)

NB. If written the other way around award half marks each time. The independent variable is the distance travelled.

5. Calculate the gradient of the graph.

a. with its rough surface in contact with the track. (4)

✓method: gradient = $\frac{\Delta y}{\Delta x}$

✓✓appropriate coordinates taken from the graph

✓ accurate calculation (0,4 cm·s^{-2} = 0,20 m·s^{-2})

b. with its smooth surface in contact with the track. (4)

✓method: gradient = $\frac{\Delta y}{\Delta x}$

✓✓appropriate coordinates taken from the graph

✓ accurate calculation (28,8 cm·s^{-2} = 0,28 m·s^{-2})

6. What quantity does the gradient of the time^2-distance graph represent? Briefly justify your answer.

$y = mx$ ✓

$\Delta x = \frac{1}{2} a \Delta t^2$ ✓

$m = \frac{1}{2} a$ ✓✓ (4)

7. Calculate and compare the acceleration of the board duster when it slides on its two different surfaces (rough and smooth).

The acceleration of the duster when it slides on its smooth surface is 0,56 m·s^2✓ which is greater than 0,40 m·s^2 when it slides on its rough surface.✓ (2)

8. Explain why the board duster accelerates at different rates when different surfaces are in contact with the track.

The duster experiences greater ✓ friction with the rough surface✓ in contact with the track. (2)

Conclusion

The smoother the surface, the greater the acceleration of the duster ✓✓ on the inclined plane. (2)

ASSESSMENTS

Topic 17: Reactions in Aqueous Solution

QUESTIONS

MULTIPLE CHOICE

1. The name of the process that takes place when ions become surrounded by water molecules in aqueous solution is called:
   A dissolving.
   B hydration.
   C precipitation.
   D ion exchange. (2)

2. Consider the following statements:
   I The electrical conductivity of a solution depends on the concentration of the ions in the solution.
   II The electrical conductivity of a solution depends on the extent of ionisation in the solution.
   III A solution only conducts electricity when there is no ionisation in the solution.

   Which statement(s) is/are correct?
   A I and II only
   B II and III only
   C I and III only
   D III only (2)

3. Which of the following anions forms a white precipitate with barium chloride solution?
   A $Cl^-(aq)$
   B $Cl^-(aq)$ and $SO_4^{2-}(aq)$
   C $SO_4^{2-}(aq)$ and $CO_3^{2-}(aq)$
   D $I^-(aq)$ and $CO_3^{2-}(aq)$ (2)

4. What type of reaction is represented by the following equation?

   $$BaCO_3(s) + 2HCl(aq) \longrightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$$

   A Ionisation
   B Precipitation
   C Redox
   D Gas forming (2)

5. Which one of the following is not an ion exchange reaction?
   A Precipitation reaction
   B Redox reaction
   C Acid base reaction
   D Gas forming reaction (2)

6. A colourless solution is tested for the presence of an anion and the following observations are made:
   I A white precipitate forms when barium chloride solution is added to it.
   II The precipitate dissolves when a few drops of dilute nitric acid are added to it.

   The anions contained in the original solution could be:
   A sulfate anions.
   B chloride anions.
   C bromide anions.
   D carbonate anions. (2)

ASSESSMENTS

LONG QUESTIONS

7. 7.1 What is meant by the term *dipole*? (2)
   7.2 What is meant by the term *dissolving*? (2)
   7.3 Explain the meaning of the term *dissociation*. (2)
   7.4 Explain, in detail, how potassium chloride crystals dissolve in water. (4)

8. 8.1 Explain why some ionic substances do not dissolve in water. (3)
   8.2 Write down balanced reaction equations for each of the following substances dissolving in water. (Remember to include phase symbols).
   I $Al(NO_3)_3$ (3)
   II $PbCl_4$ (3)

9. 9.1 What is meant by the term *electrolyte*? (2)
   9.2 Why is the brightness of a light bulb used to indicate the extent of conductivity of an electrolyte solution? (3)
   9.3 List two factors that have an effect on how brightly a light bulb glows when testing an electrolyte solution. (2)

10. 10.1 Explain how the two factors that you mentioned in the previous question have the effect you described. (4)
    10.2 Describe, in detail, how a solution of sodium bromide is able to conduct electricity. (4)

11. You are provided with three colourless solutions, A, B and C, which contain sodium chloride, sodium bromide and sodium iodide respectively. Describe a way in which you can distinguish which solution contains which substance. (4)

12. Write down balanced net ionic equations for each of the following reactions and then state what type of reaction takes place.
    - 12.1 Magnesium carbonate reacts with sulfuric acid (5)
    - 12.2 Barium chloride solution reacts with potassium sulfate solution (4)
    - 12.3 Potassium hydroxide solution reacts with nitric acid (4)

MARKING GUIDELINES

MULTIPLE CHOICE

1. B✓ ✓ The statement given is the definition of hydration. [CL 2] (2)
2. A✓ ✓ Statement III is not correct because liquids will conduct electricity only when there are ions present in the solution. [CL 2] (2)
3. C✓ ✓ Cl^- ions and I^- ions only form precipitates with silver nitrate solution not with barium chloride solution. [CL 3] (2)
4. D✓ ✓ One of the products in the equation given is a gas, so this represents a gas forming reaction. [CL 3] (2)
5. B✓ ✓ A redox reaction does not involve ion exchange. It involves the transfer of electrons. [CL 2] (2)
6. D✓ ✓ Sulfate ions also form a white precipitate with barium chloride solution but the precipitate does not dissolve in nitric acid. [CL 3] (2)

LONG QUESTIONS

7. 7.1 A dipole is a molecule which has one end that is partially charged with respect to the opposite end. ✓ ✓ [CL 1] (2)
   7.2 Dissolving is the process by which solid crystals break up into their individual molecules or ions in water. ✓ ✓ [CL 1] (2)
   7.3 Dissociation is the separation of positive and negative ions from each other when they go into solution. ✓ ✓ [CL 1] (2)
   7.4 In potassium chloride, the potassium ions are positive and the chloride ions are negative. The positive ends of the water molecules are attracted to the chloride ions ✓ and the negative ends are attracted to the potassium ions. ✓ A lot of water molecules surround each ion, ✓ and they attract the ions sufficiently to make them leave the lattice and go into solution. ✓ [CL 3] (4)

8. 8.1 In some ionic compounds, the attractive forces between the positive and negative ions are so strong, ✓ that the water molecules can't attract them strongly enough ✓ to make them go into solution. ✓ [CL 3] (3)
   8.2 I $Al(NO_3)_3(s)$✓ $\longrightarrow Al^{3+}(aq)$✓ $+ 3NO_3^-(aq)$✓ ✓ [CL 2] (3)
   II $PbCl_4(s)$✓ $\longrightarrow Pb^{4+}(aq)$✓ $+ 4Cl^-(aq)$✓ ✓ [CL 2] (3)

9. 9.1 An electrolyte is a solution that conducts electricity because it contains ions. ✓ ✓ [CL 1] (2)
   9.2 The brightness of a light bulb in a circuit such as this depends on the current passing through it. ✓ The more ions that reach the electrodes per unit time, the greater the current. ✓ So, the current and the brightness indicate the extent of ionisation. ✓ [CL 4] (3)

9.3 Two factors are:
- The concentration of the ions in the solution. ✓
- The extent of ionisation of the substance in solution. ✓ [CL 2] (2)

10. 10.1 The higher the concentration of the ions in solution, the greater the number of ions reaching the electrodes per unit time ✓ and the greater the current. ✓
The higher the extent of solution of the substance the greater the number of ions in the solution ✓ and the greater the number of ions reaching the electrodes per unit time. ✓ [CL 4] (4)

10.2 A solution of sodium bromide contains positive sodium ions and negative bromide ions. ✓ The positive ions are attracted to the negative electrode ✓ and the negative ions are attracted to the positive electrode. ✓ The movement of ions makes up a current in the solution. ✓ [CL 4] (4)

11. Add a few drops of silver nitrate solution to each of the test tubes. ✓ The one that produces a white precipitate contains the sodium chloride solution. ✓ The one that produces a light yellow precipitate is the sodium bromide solution. ✓ The one that produces a yellow precipitate is the sodium iodide solution. ✓ [CL 2] (4)

12. 12.1 $CO_3^{2-}(aq)$ ✓ + $2H^+(aq)$ ✓ → $CO_2(g)$ ✓ + $H_2O(l)$ ✓ gas forming reaction ✓
[CL 3] (5)

12.2 $Ba^{2+}(aq)$ ✓ + $SO_4^{2-}(aq)$ ✓ → $BaSO_4(s)$ ✓ precipitation reaction ✓ [CL 3] (4)

12.3 $OH^-(aq)$ ✓ + $H^+(aq)$ ✓ → $H_2O(l)$ ✓ acid base reaction ✓ [CL 3] (4)

Topic 18: Quantitative Aspects of Chemical Change

QUESTIONS

MULTIPLE CHOICE

1. Which one of the following does NOT consist of approximately 1 mole of atoms?
   A 19 g of fluorine atoms
   B 23 g of sodium
   C 71 g of chlorine gas
   D $6,022 \times 10^{23}$ atoms of helium (2)

2. Which of the following statements is/are true?
   I One mole of any element or compound will always contain the same number of elementary particles.
   II The Avogadro constant is the number of atoms only in one mole.
   III The relative atomic mass of any element, expressed in grams, contains one mole of atoms of that element.
   A I and III
   B II and III
   C II only
   D I only (2)

3. The number of moles of oxygen gas in $6,72\,dm^3$ at STP is ...
   A 3,00.
   B 0,30.
   C 0,13.
   D 0,15. (2)

4. 1 mole is the number of atoms in ...
   A 6 g of carbon.
   B 12 g of magnesium.
   C 40 g of calcium.
   D 10 g of neon. (2)

5. $11,2\,dm^3$ of a certain gas, at STP, has a mass of 20 g. The gas could be:
   A SO_2
   B Ne
   C Ar
   D CH_4 (2)

ASSESSMENTS

6. Which one of the following contains $6,022 \times 10^{23}$ molecules?
   A 10 g of potassium
   B 1 g of hydrogen gas
   C 4 g of helium gas
   D 28 g of nitrogen gas (2)

LONG QUESTIONS

7. Calculate:
   7.1 the number of moles of molecules in 6,3 g of HNO_3. (3)
   7.2 the mass of $11,2\,dm^3$ of CO_2 at STP. (4)

8. Which one of the following contains the greater number of moles of oxygen atoms?
   a. 21 g of HNO_3 or
   b. 21 g of CO_2
   Show all calculations used to arrive at your answer. (7)

9. 9.1 A calcium mineral consists of 29,40% calcium, 23,50% sulfur and 47,10% oxygen by mass. Determine the empirical formula of the mineral. (5)
   9.2 Calculate the percentage composition by mass of calcium hydrogen carbonate, $Ca(HCO_3)_2$. (5)

10. A sample of a certain compound contains 0,3 g of carbon, 0,05 g of hydrogen and 0,95 g of fluorine. The compound has a molar mass of $104\ g{\cdot}mol^{-1}$.
   Determine:
   10.1 the empirical formula of the compound. (5)
   10.2 the molecular formula of the compound. (2)

11. The reaction between magnesium and dilute hydrochloric acid is represented by the balanced reaction equation below:

$$Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$$

   Calculate:
   11.1 the mass of magnesium chloride produced when 1,5 g of magnesium reacts completely with dilute hydrochloric acid. (5)
   11.2 the volume of hydrogen gas produced, at STP, when 17,75 g of hydrochloric acid reacts completely with magnesium. (5)

12. The reaction equation represents the reaction that occurs when methane gas burns in air:

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

   12.1 Calculate the mass of oxygen that reacted with methane to produce 3 mol of water molecules. (3)
   12.2 Calculate the mass of carbon dioxide produced when 3,2 g of methane burn completely in air. (5)

MARKING GUIDELINES

MULTIPLE CHOICE

1. C✓ ✓ 71 g of chlorine contains 1 mole of molecules of chlorine, not atoms. Chlorine occurs in nature as diatomic molecules of Cl_2. [CL 3] (2)

2. D✓ ✓ Statement II is incorrect because the Avogadro constant is the number of elementary particles, which are not necessarily atoms. Statement III is incorrect because some elements consist of diatomic molecules. [CL 2] (2)

3. B✓ ✓ $n = \frac{V}{V_m}$

   $= \frac{6,72}{22,4}$

   = 0,3 mol [CL 2] (2)

4. C✓ ✓ The other options are all 0,5 mol. Remember that [CL 2] (2)

   $n = \frac{m}{M}$

5. C✓ ✓ $11,2\,dm^3$ corresponds to 0,5 mol. This means that the molar mass of the gas must be $40\,g{\cdot}mol^{-1}$. The only gas of those given that has this molar mass is Ar. [CL 4] (2)

6. D✓ ✓ The only two substances that are made up of molecules are B and D. $6,022 \times 10^{23}$ molecules is 1 mole. The molar mass of hydrogen (H_2) is $2\,g{\cdot}mol^{-1}$. [CL 3] (2)

LONG QUESTIONS

7. 7.1. $M(HNO_3) = 1 + 14 + (3 \times 16)$ $\quad n = \frac{m}{M}$

   $= 63\,g{\cdot}mol^{-1}$ $\quad = \frac{6,3✓}{63✓}$

   = 0,1 mol ✓ [CL 2] (3)

   7.2 First determine the number of moles of gas.

   $n = \frac{V}{V_m}$

   $= \frac{11,2}{22,4}$✓

   =0,5 mol ✓

   Now determine the mass:

   $m = n \times M$

   $= 0,5 \times 44$ ✓

   = 22 g ✓ [CL 3] (4)

ASSESSMENTS

8. First calculate the number of moles of molecules of each:

a. $n = \frac{m}{M}$

$= \frac{21}{63}$ ✓

$= 0{,}33$ mol ✓

b. $n = \frac{m}{M}$

$= \frac{21}{44}$ ✓

$= 0{,}48$ mol ✓

Now calculate the number of moles of oxygen atoms in each:

a. In HNO_3, there are 3 mol of oxygen atoms per mole of molecules

$\therefore$ no.of moles of $\text{O atoms} = 0{,}33 \times 3 = 0{,}99\,\text{mol}$ of O atoms. ✓

b. In CO_2, there are 2 mol of oxygen atoms per mole of molecules

$\therefore$ no.of moles of $\text{O atoms} = 0{,}48 \times 2 = 0{,}96\,\text{mol}$ of O atoms. ✓

So, 21 g of HNO_3 contains more moles of oxygen atoms. ✓ [CL 4] (7)

9. 9.1 Assuming we have a 100 g sample of the mineral, then

$n_{Ca} = \frac{m}{M} = \frac{29{,}4}{40} = 0{,}74\,\text{mol}$✓

$n_S = \frac{m}{M} = \frac{23{,}5}{32} = 0{,}73\,\text{mol}$✓

$n_O = \frac{m}{M} = \frac{47{,}1}{16} = 2{,}94$✓

Ratio of $Ca{:}S;O = 0{,}74{:}0{,}73{:}2{,}94$ (divide through by 0,73)

Whole number ratio $= 1{:}1{:}4$ ✓

Empirical formula is $CaSO_4$ ✓ [CL 2] (5)

9.2 First determine the molar mass:

$M[Ca(HCO_3)_2] = 40 + 2(1 + 12 + 3 \times 16)$

$= 162\,\text{g·mol}^{-1}$ ✓

$\%Ca = \frac{40}{162} \times 100 = 24{,}70\%$ ✓

$\%H = \frac{2}{162} \times 100 = 1{,}23\%$ ✓

$\%C = \frac{24}{162} \times 100 = 14{,}81\%$ ✓

$\%O = \frac{96}{162} \times 100 = 59{,}25\%$ ✓ [CL 2] (5)

10. 10.1 Determine the number of moles of each element:

$n_C = \frac{m}{M} = \frac{0{,}3}{12} = 0{,}025$ ✓

$n_H = \frac{m}{M} = \frac{0{,}05}{1} = 0{,}05$ ✓

$n_F = \frac{m}{M} = \frac{0{,}95}{19} = 0{,}05$ ✓

Ratio of $C{:}H{:}F = 0{,}025{:}0{,}05{:}0{,}05$ (divide through by 0,025)

Whole number ratio $= 1{:}2{:}2$ ✓

Empirical formula $= CH_2F_2$ ✓ [CL 3] (5)

10.2 First determine the molar mass of the empirical formula:
$M(CH_2F_2) = 12 + (2 \times 1) + (2 \times 19) = 52\ g{\cdot}mol^{-1}$ ✓
The molar mass of the compound is $104\ g{\cdot}mol^{-1}$
The molar mass of the compound is 2 times the molar mass of the empirical formula, so the molecular formula will be $C_2H_4F_4$. ✓ [CL 4] (2)

11. 11.1 First calculate the number of moles of magnesium:
$n = \frac{m}{M}$
$= \frac{1,5}{24}$ ✓
= 0,0625 mol ✓
1 mol Mg produces 1 mol $MgCl_2$
0,0625 mol Mg produces 0,0625 mol $MgCl_2$
$M(MgC\ell_2) = 24 + (2 \times 35,5) = 95\ g{\cdot}mol^{-1}$ ✓
$m = nM$
$= 0,0625 \times 95$ ✓
= 5,94 g ✓
[CL 2] (5)

11.2 Calculate the number of moles of HCl
$n = \frac{m}{M}$
$= \frac{17,75}{36,5}$ ✓
=0,49 mol ✓
2 mol HCl produces 1 mol H_2.
0,49 mol HCl produces 0,25 mol H_2. ✓
$V = n \times V_m$
$= 0,25 \times 22,4$ ✓
$= 5,6\ dm^3$ ✓ [CL 2] (5)

12. 12.1 1 mole of methane produces 2 moles of water
1,5 moles of methane produces 3 moles of water ✓
$m = n \times M$
$= 1,5 \times 16$ ✓
= 24 g ✓ [CL 2] (3)

12.2 Calculate the number of moles of methane:
$n = \frac{m}{M}$
$= \frac{3,2}{16}$ ✓
=0,2 mol ✓
1 mol CH_4 produces 1 mol CO_2.
0,2 mol CH_4 produces 0,2 mol CO_2. ✓
$m = n \times M$
$= 0,2 \times 44$ ✓
= 8,8 g ✓ [CL 2] (5)

ASSESSMENTS

Topic 19: Vectors

QUESTIONS

MULTIPLE CHOICE

1. Which of the following quantities is not a vector quantity?
   A distance
   B force
   C velocity
   D acceleration (2)

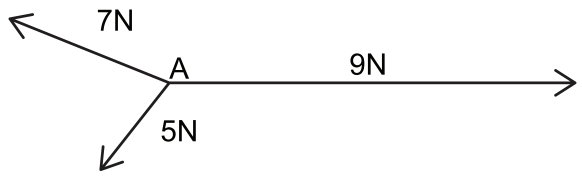
2. Which of the following pairs of quantities has one scalar and one vector quantity?
   A distance and speed
   B displacement and velocity
   C acceleration and time
   D force and acceleration (2)

3. A father drove his children to school which is located 15 km east from their home. He then drove from the school to his workplace which is 10 km east of the school. After work the man drove 15 km west to the shop, and finally he drove back home.
   Which of the following statements is TRUE?
   A The total distance the man travelled from home to his workplace is 30 km.
   B The magnitude of the displacement from his home to the shop is 25 km.
   C The magnitude of the displacement from the school from the shop is 5 km.
   D The magnitude of the displacement for the whole trip is 40 km. (2)

4. An athlete jogs along the following route in the early morning. She runs 2 km east then 6 km north. Then she jogs for 5 km west and 6 km south. At this stage she stops and takes a short rest. What is the magnitude of her displacement from her home at this point?
   A 1 km
   B 3 km
   C 7 km
   D 19 km (2)

5. Which statement best describes a property of the resultant of the two forces?
   A The resultant is always in the same direction as the two forces.
   B The resultant produces the same effect as the two forces acting together.
   C The resultant keeps the object in equilibrium (at rest).
   D The resultant is in the same direction as the equilibrant. (2)

*6. Three forces keep a body at point A in equilibrium. If the force of 5 N is suddenly removed, the magnitude of the resultant force exerted on the body at A will be…



A 2 N
B 5 N
C 7 N
D 9 N (2)

7. Two displacement vectors of magnitudes 20 cm and 80 cm are added. Which one of the following is the ONLY possible choice for the magnitude of the resultant?

A 0 cm
B 28 cm
C 82 cm
D 114 cm (2)

ASSESSMENTS

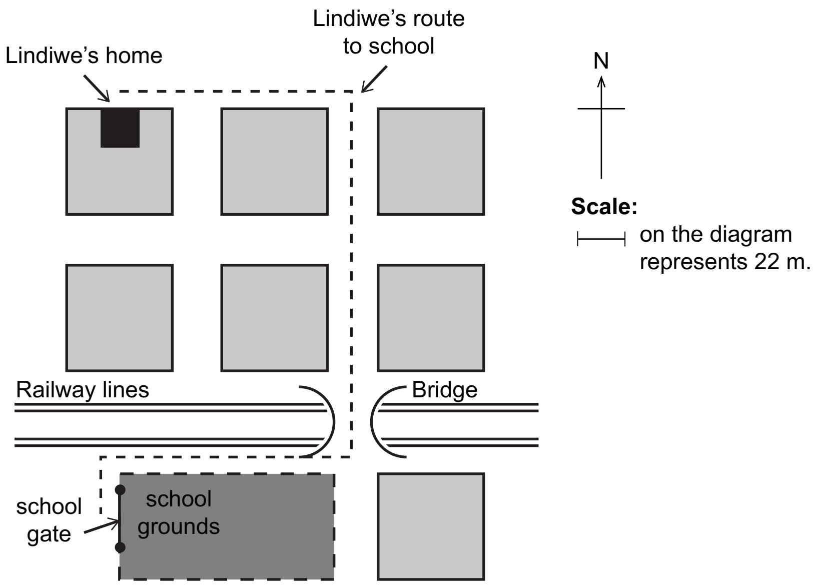
LONG QUESTIONS

8. Read and use the facts contained in the following statements to answer the questions that follow.

I	Neo walks 800 m in a straight line on a bearing of 210º.
II	Daniel walks 50 m due north then turns aroun and walks 150 m due south.
III	Unathi walks four times round a circular athletics track with a circumference of 440 m and stops when he gets back to his starting position again.

8.1 Clearly distinguish between *distance* and *displacement*. (3)
8.2 Write down the distance walked by Neo. (2)
8.3 Write down the magnitude of the displacement of Unathi. (2)
8.4 Calculate Daniel's displacement. (3)

9. Lindiwe walks **to school** every morning as shown in the diagram.



9.1 Find the distance that Lindiwe walks every morning from home to the school gates. (2)

9.2 What is her displacement at the school gate? (2)

9.3 What is her displacement when she gets home? (1)

10. Three forces, as descibed below, are simultaneously applied to an object.

a) 37 N to the right

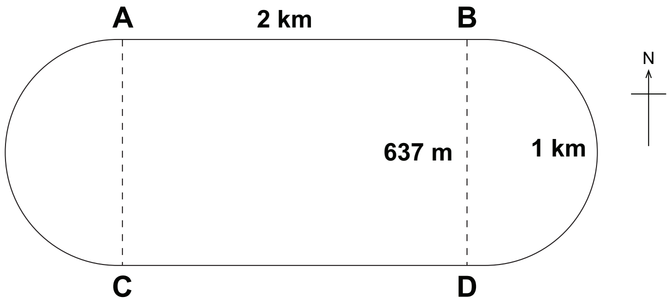
b) 20 N to the right

c) 35 N to the left

10.1 Define *the resultant force.* (2)

10.2 Determine the resultant force acting on the object, by using a vector diagram or by calculation. Show your method clearly. (4)

11. A car is driven around a racetrack at a constant speed. The track has the dimensions shown in the diagram below. The straight stretch is 2 km long, in an easterly direction. The semi-circular curve is 1 km long. The car travels clockwise around the track (from A to B to C to D and back to A again).



11.1 What is the distance travelled in one complete lap of the track? (2)

11.2 What is the displacement of the car after one complete lap? (2)

11.3 Find the magnitude of the car's displacement at point C. (2)

11.4 What distance has the car covered when it reaches point C? (2)

MARKING GUIDELINES

MULTIPLE CHOICE

1. A✓ ✓ Distance is the length of the path travelled. It requires only magnitude (and does not require direction). [CL 2] (2)

2. C✓ ✓ Acceleration is a vector quantity. Time is a scalar. [CL2] (2)

3. C✓ ✓ The school is 15 km east of the home, and his workplace is a further 10 km east. He returns to his home by travelling west for 15 km to the shop, then going home.
Therefore the shop is 10 km east of his home. The school is 15 km east of his home, therefore the school is 5 km from the shop. [CL 3] (2)

4. B✓ ✓ Taking her displacements in the east-west directions:
2 km east + 5 km west = 3 km west.
Taking her displacement in the north-south directions:
6 km north + 6 km south = 0 km
Her overall displacement is therefore 3 km west. [CL 4] (2)

5. B✓ ✓ This statement is a definition of the resultant force. [CL 2] (2)

6. B✓ ✓ The resultant of all three forces is zero. Removing one force leaves the other two with a resultant that acts in the opposite direction to the force that is removed and is of the same magnitude as the force which is removed. [CL 4] (2)

7. C✓ ✓ The minimum resultant is 80 cm – 20 cm = 60 cm therefore options A and B are invalid. The maximum resultant is 80 cm + 20 cm = 100 cm therefore option D is invalid. [CL 3] (2)

LONG QUESTIONS

8. 8.1 Distance is the total length of the path travelled.✓
Displacement is the change in position. ✓ ✓ [CL1] (3)
8.2 800 m ✓ ✓ [CL1] (2)
8.3 0 m ✓ ✓ (He returns to his original position) [CL2] (2)
8.4 Displacement = +50 + (-150) ✓ (method)
= -100 (accuracy)
= 100 m✓south✓ (SI units; direction) [CL2] (3)

9. 9.1 Measurement of the scale length = 6 mm
Therefore 6 mm represents 22 m. ✓
Distance = (32 + 42 + 33 + 5 + 2) × 22✓
= 2 508 m (2,508 km) ✓ [CL 2] (3)

9.2 Measured distance from home to school = 54 mm
Displacement = 54 × 22 = 1 188 m✓ south✓ [CL 2] (2)

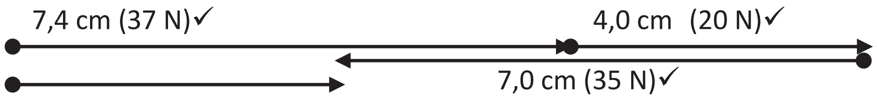
9.3 0 m✓ (There is no change in position because she has come home again.) [CL 3] (1)

10 10.1 The resultant force is the single force which produces the same effect as all the other forces acting together. ✓ ✓ [CL1] (2)

10.2 ALTERNATIVE 1.

Choose 'to the right" as the positive direction. ✓	(Choosing EITHER direction as positive)
Resultant force = +37✓ + (+20)✓ + (-35) ✓ = +22 N	(Appropriate choice of signs)
Resultant force = 22 N ✓ to the right ✓	(Accuracy; SI units; direction) [CL 3] (6)

ALTERNATIVE 2.
Scale: 1 cm: 5 N ✓



Resultant force: 4,4 cm i.e. 22 N ✓right✓

[CL3] (6)

11.1 Distance = 2 + 1 + 2 + 1 ✓ (method)
= 6 km ✓ (accuracy; SI units) [CL2] (2)

11.2 0 m ✓ ✓ [CL3] (2)

11.3 637 m ✓ South (S) ✓ (accuracy; Si units) (direction) [CL3] (2)

11.4 Distance = 2 + 1 + 1 ✓ (method)
= 5 km✓ (accuracy; SI units) [CL2] (2)

Topic 20: One-dimensional Motion and Average Speed, Average Velocity and Acceleration

QUESTIONS

MULTIPLE CHOICE

1. A car accelerates from 10 $m \cdot s^{-1}$ to 30 $m \cdot s^{-1}$ in 2 s. What is the magnitude of the car's acceleration (in $m \cdot s^{-2}$)?
   A 0,5
   B 0,1
   C 10
   D 20 (2)

2. Andile drives from town **A** to town **B** and back to town **A** in 2 hours. The distance between town **A** and town **B** is 60 km. What is the magnitude of the average velocity (in $km \cdot h^{-1}$) for the entire trip?
   A 0
   B 30
   C 60
   D 120 (2)

3. An object moves in the positive x-direction with positive velocity and a positive constant acceleration *a*. After 3 s, its acceleration changes to a constant value of $-a$. Which row of the table below is CORRECT concerning the velocity and displacement of the object **immediately** after this sudden change in acceleration takes place?

	Velocity	Displacement
A	Decreases and remains positive	Increases
B	Decreases and becomes negative	Increases
C	Increases and remains positive	Decreases
D	Increases and becomes negative	Decreases

(2)

4. A truck driver is in a rush to deliver the load. She travels 45 km at an average speed of 60 $km \cdot h^{-1}$. She returns along the same route at an average speed of 30 $km \cdot h^{-1}$. What is her average speed ($km \cdot h^{-1}$) for the trip?
   A 24
   B 40
   C 45
   D 48 (2)

ASSESSMENTS

5. The instantaneous velocity of an object is always equal to …
   A the magnitude of the average speed of the object.
   B the total displacement divided by the total time taken.
   C a very small displacement of the object divided by time taken.
   D the displacement of the object divided by the time taken over a very small interval of time. (2)

LONG QUESTIONS

6. There is no atmosphere on the Moon. Astronauts carried out experiments on the lunar surface in the early 1970's. In one such experiment when a feather was dropped from rest, it fell 20,75 m in 5 s.
   6.1 Calculate the average speed of the feather. (3)
   6.2 Determine the acceleration of the feather using the fact that its average speed is equal to its instantaneous speed at exactly halfway through the time (that is, at 2,5 s). (4)
   6.3 Would the feather fall at a faster or slower rate if it fell through a vacuum on earth? (1)

7. A stone falls from rest from the top of a 15 m high cliff. It is in the air for 1,75 s.
   7.1 Calculate its average velocity. (4)
   7.2 Its average velocity is equal to its instantaneous velocity at halfway through the time (that is, at 0,875 s). Determine the magnitude of its velocity just before it hits the ground. (3)
   7.3 Define *acceleration*. (2)
   7.4 Calculate the magnitude of the stone's acceleration. (3)

8. A professional cyclist is able to reach a speed of 100 $km{\cdot}h^{-1}$ by starting from rest and pedalling flat out for a distance of 3 km along a straight track. Assume that the rate of change of the cyclist's speed is uniform.
   8.1 Show that 100 $km{\cdot}h^{-1}$ is equivalent to 27,78 $m{\cdot}s^{-1}$. (2)
   8.2 Calculate the average speed of the cyclist. (2)
   8.3 Calculate how long (in minutes) it takes the cyclist to reach this top speed. (4)

9. A tractor accelerates uniformly from rest to 4 $m{\cdot}s^{-1}$ in 20 s. It then travels at a steady speed for 440 m, and finally comes to rest 10 s later, having travelled a total of 500 m.
   9.1 Define *uniform acceleration*. (3)
   9.2 Calculate the magnitude of the acceleration of the tractor during the first 20 s. (3)
   9.3 Calculate the magnitude of the average velocity of the tractor for the entire journey. (5)
   9.4 Calculate the magnitude of the acceleration of the tractor during the last 10 s. (3)

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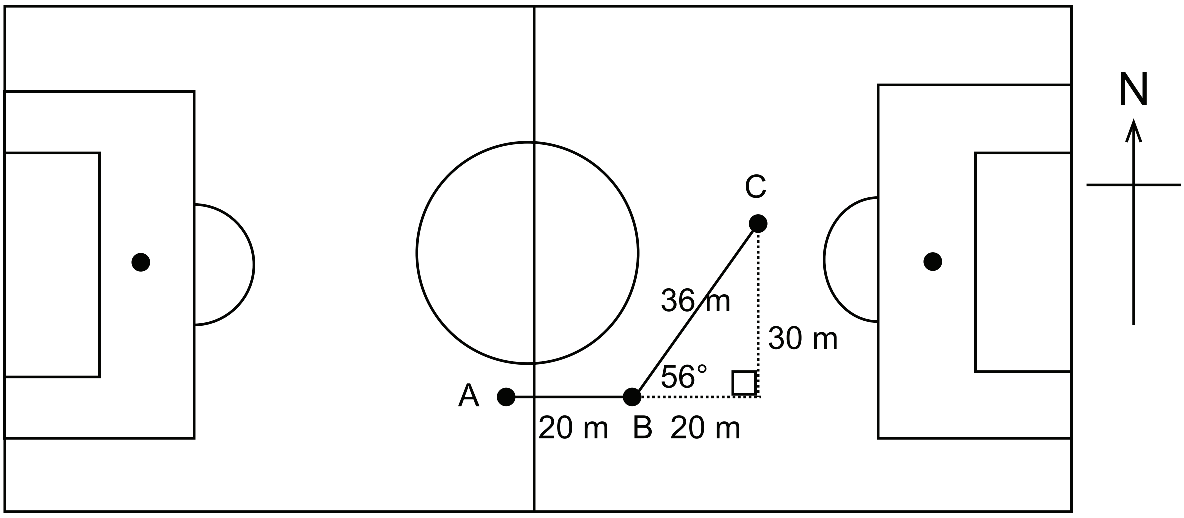
10. A boy throws a ball into the air from an initial height of 1,20 m. The ball travels upwards to a maximum height of 0,60 m above his hand, then he allows it to fall to the ground and catches it at the top of its bounce of 0,90 m.
    - 10.1 Draw a labelled diagram of the ball's position from its initial position A, to its final position D, taking the ground as the reference point. (Maximum height occurs at position B and the bounce occurs at position D.) (4)
    - 10.2 The ball takes 1,14 s to fall to the ground from the time it leaves the boy's hand. During this time, calculate:
        - 10.2.1 the distance travelled by the ball. (3)
        - 10.2.2 the average speed of the ball. (3)
        - 10.2.3 the displacement of the ball. (3)
        - 10.2.4 the magnitude of the average velocity of the ball. (3)
    - 10.3 Explain why the magnitude of the resultant displacement of the ball when the boy catches it at the top of its bounce is less than the total distance travelled by the ball. (3)

*11. In a soccer match, a player runs 20 m due East in 10 s from position **A** to position **B** (as shown in the diagram below). He then breaks through the opposition's defence and is able to run to position **C** (on a bearing of 034°) in another 10 s. Position **C** is 20 m East of **B** and 30 m North of **B**.



- 11.1 What is the difference between distance and displacement? Illustrate your answer with an example of each, referring to positions **A**, **B** and **C**, from the situation above. (4)
- 11.2 Calculate the magnitude of the player's average velocity ...
    - 11.2.1 from **A** to **B**. (3)
    - 11.2.2 from **B** to **C**. (3)
- 11.3 Draw an accurate labelled scale diagram to determine the **magnitude** of the player's **resultant change in position** from **A** to **C**. (5)
- 11.4 Calculate the player's average speed from **A** to **C**. (3)
- 11.5 Calculate magnitude of the player's average velocity from **A** to **C**. (3)

ASSESSMENTS

MARKING GUIDELINES

MULTIPLE CHOICE

1. C✓ ✓ $a = \frac{\Delta v}{\Delta t} = \frac{30 - 10}{2} = 10\,m{\cdot}s^{-2}$ [CL 2] (2)

2. A✓ ✓ $\text{average velocity} = \frac{\text{total displacement}}{\text{total time}} = \frac{0}{2} = 0\,km{\cdot}h^{-1}$ [CL 2] (2)

3. A✓ ✓ The car was moving forward at a particular velocity. When its acceleration changes to a negative value, the driver has put her foot on the brake. The car is slowing down. So its velocity decreases. But it is still moving forward so its displacement increases (at a decreasing amount). [CL 4] (2)

4. B✓ ✓ The car moves at 60 km·h^{-1} for 45 km. It takes $\frac{45}{60} = 0{,}75\,h$ to cover this distance.

   On the return trip the car travels at 30 km·h^{-1}. It covers the same distance of 45 km.

   It takes $\frac{45}{30} = 1{,}5\,h$ to cover this distance.

   The total distance covered it $45 + 45 = 90\,km$.

   The total time taken $= 0{,}75 + 1{,}5 = 2{,}25\,h$.

   $\text{The average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{90}{2{,}25} = 40\,km{\cdot}h^{-1}$ [CL 3] (2)

5. D✓ ✓ This is the definition of instantaneous velocity. [CL 1] (2)

LONG QUESTIONS

6. 6.1 Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

   $= \frac{20{,}75}{5}$ ✓ (substitutions)

   $= 4{,}15\,m{\cdot}s^{-1}$ ✓ (accuracy; SI units) [CL2] (3)

   6.2 $a = \frac{\Delta v}{\Delta t}$ ✓ (method)

   $= \frac{4{,}15}{2{,}5}$ ✓ (substitutions)

   $= 1{,}66\,m{\cdot}s^{-2}$ ✓ downwards ✓ (accuracy; SI units) (direction) [CL3] (4)

   6.3 Faster (on earth) ✓ [CL2] (1)

7. 7.1 Average velocity $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

   $= \frac{15}{1{,}75}$ ✓ (substitutions)

   $= 8{,}57\,m{\cdot}s^{-1}$ ✓ (accuracy; SI units)

   downwards ✓ (direction) [CL3] (4)

7.2 Average velocity $= \frac{v_i + v_f}{2}$ ✓ (method)

$\frac{0 + v_f}{2} = 8,57$ ✓ (substitutions)

$v_f = 17,14\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL3] (3)

7.3 Acceleration is the rate of change of velocity. ✓ ✓ [CL1] (2)

7.4 $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{17,14 - 0}{1,75}$ ✓ (substitutions)

$= 9,79\ \text{m·s}^{-2}$ ✓ (accuracy; SI units) [CL2] (3)

8. 8.1 $100\ \text{km·h}^{-1} = 100 \times \frac{1\,000✓}{60 \times 60✓} = 27,78\ \text{m·s}^{-1}$ (method) [CL1] (2)

8.2 $a = \frac{v_f + v_i}{2}$ ✓ (method)

$= \frac{28,78 - 0}{2}$ (substitutions)

$= 13,85\ \text{m·s}^{-1}$ ✓ (accuracy; SI units) [CL2] (2)

8.3 Average speed $= \frac{\text{distance}}{\text{time}}$

Time $= \frac{\text{distance}}{\text{average speed}}$ ✓ (method)

$= \frac{3\,000✓}{13,85}$ ✓ (conversion of km to m) (substitutions)

$= 216,61\text{s}$

$= \frac{216,61}{60}$

= 3,61 minutes ✓ (accuracy; SI units) [CL3] (4)

9. 9.1 The rate of change of velocity ✓ ✓ is constant. ✓ [CL1] (3)

9.2 $a = \frac{v_f + v_i}{2}$ ✓ (method)

$= \frac{4 - 0}{20}$ ✓ (substitutions)

$= 0,2\ \text{m·s}^{-2}$ ✓ (accuracy; SI units) [CL2] (3)

9.3 Average velocity $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

Time $= \frac{\text{distance}}{\text{average velocity}}$

$= \frac{440}{4}$ ✓ (substitutions)

$= 110\ \text{s}$

Total time = 20 + 110 + 10 = 140 s ✓ (accuracy)

Average velocity $= \frac{500✓}{140} = 3,57\ \text{m·s}^{-1}$✓ (accuracy; SI units) [CL4] (5)

ASSESSMENTS

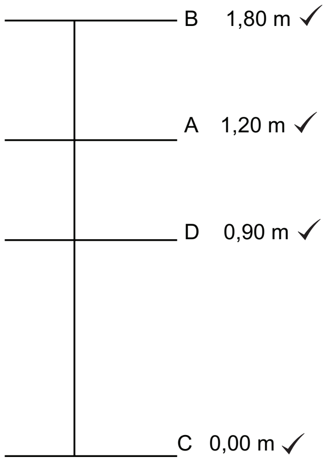
9.4 $a = \frac{v_f - v_i}{2}$ ✓ (method)

$= \frac{0 - 4}{10}$ ✓ (substitutions)

$= -0,4\ m \cdot s^{-2}$ ✓ (accuracy; SI units) OR

$= 0,4\ m \cdot s^{-2}$ (accuracy; SI units) [CL3] (3)

10. 10.1



[CL3] (4)

10.2 10.2.1 $0,6$✓ + $1,8$✓ = $2,4\ m$ ✓ [CL3] (3)

10.2.2 average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{2,4}{1,14}$ ✓ (substitutions)

$= 2,11\ m \cdot s^{-1}$ ✓ (accuracy; SI units) [CL2] (3)

10.2.3 $1,20\ m$ ✓ ✓ down (accuracy; SI units) (direction) [CL2] (3)

10.2.4 average velocity $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{1,20}{1,44}$ ✓ (substitutions)

$= 0,83\ m \cdot s^{-1}$ ✓ (accuracy; SI units) [CL3] (3)

10.3 The magnitude of the resultant displacement of the ball is equal to its final position minus its initial position.

$\Delta x = 0,90 - 1,20$

$= -0,30$

$= 0,30\ m$ downward ✓

The total distance travelled $= 0,6 + 1,8 + 0,9$

$= 3,3\ m$ ✓

The total distance is equal to its path length, whereas the resultant displacement is its change in position. ✓ [CL3] (3)

*11. 11.1 Distance is path length ✓ e.g. when the player moved from A to B to C, the distance is equal to the length of AB + the length of AC. ✓

Displacement is the change in position ✓ e.g. when the player moves from A to B passing through C his displacement is the length of AC and the direction is in the direction from A to C. ✓ [CL2] (4)

11.2 11.2.1 Average velocity (A to B) $= \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{20}{10}$ ✓ (substitutions)

$= 2\ m{\cdot}s^{-1}$ ✓ (accuracy; SI units)

[CL3] (3)

11.2.2 Displacement from B to C = 36 m ✓ (accuracy)

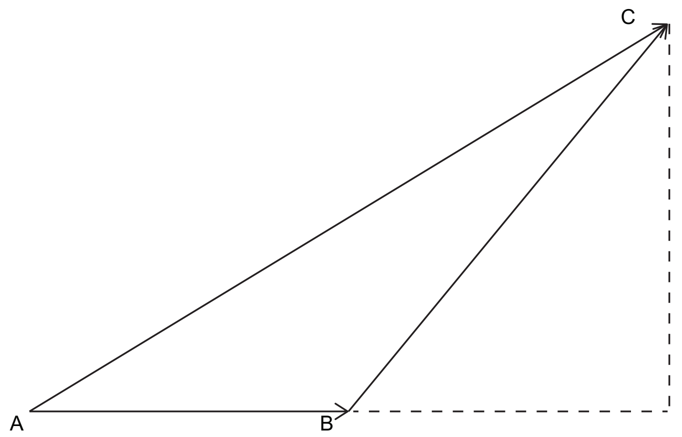
Average velocity (B to C) $= \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{36}{10}$ ✓✓ (substitutions)

$= 3{,}6\ m{\cdot}s^{-1}$ ✓ (accuracy; SI units)

[CL3] (5)

11.3



Scale: 1 cm = 4 m ✓ (appropriate scale)

Correct lengths and labels ✓ ✓ ✓

Displacement = 46 m ✓ (allow 45 m – 48 m error in measurement)

[CL4] (5)

11.4 Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)

$= \frac{20 + 36}{20}$ ✓ (substitutions)

$= 2{,}8\ m{\cdot}s^{-1}$ ✓ (accuracy; SI units)

[CL3] (3)

11.5 Average velocity $= \frac{\text{displacement}}{\text{time}}$ ✓ (method)

$= \frac{46}{20}$ ✓ (substitutions; c.o.e.)

$= 2{,}3\ m{\cdot}s^{-1}$ (accuracy; SI units)

[CL3] (3)

ASSESSMENTS

Topic 21: Instantaneous Speed and Velocity and Equations of Motion

QUESTIONS

MULTIPLE CHOICE

1. Which ONE of the following statements is TRUE of a body that accelerates at a constant rate?
   A The rate of change of velocity with time remains constant.
   B The velocity of the body increases by increasing amounts in equal time intervals.
   C The position changes by the same amount in equal time intervals.
   D The rate of change of position with time remains constant. (2)

2. Joseph leans on the railing of a tall building. His cell phone drops out of his hand and falls to the ground. Ignoring any effects of air resistance, which ONE of the following combinations of velocity and acceleration correctly describes the motion of the cell phone?

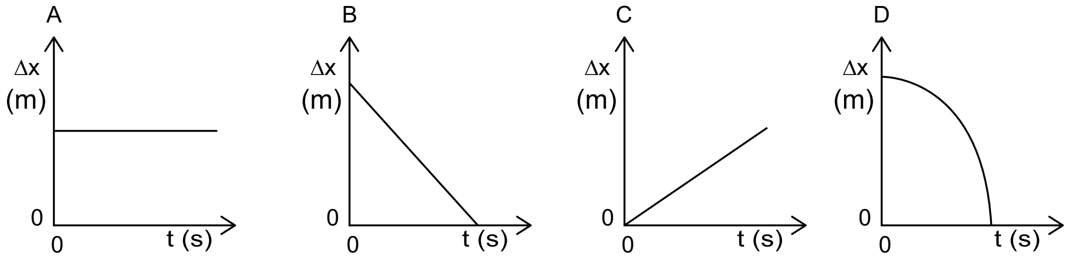
	Velocity	Acceleration
A	Increases	Increases
B	Decreases	Increases
C	Remains constant	Remains constant
D	Increases	Remains constant

(2)

3. Which quantity does the area under a velocity – time graph represent?
   A distance
   B displacement
   C acceleration
   D position (2)

4. Which quantity does the gradient of a velocity – time graph represent?
   A distance
   B displacement
   C acceleration
   D position (2)

5. Which graph correctly shows the variation of position versus time for an object moving with constant velocity towards you?



(2)

6. Which of the following statements is/are TRUE about a vehicle travelling at a constant velocity?

   I It travels in a straight line.
   II It travels at the same speed as the magnitude of its velocity.
   III Its displacement increases by the same amount in each time interval.

   A I only
   B I and II only
   C II and III only
   D All the statements are true. (2)

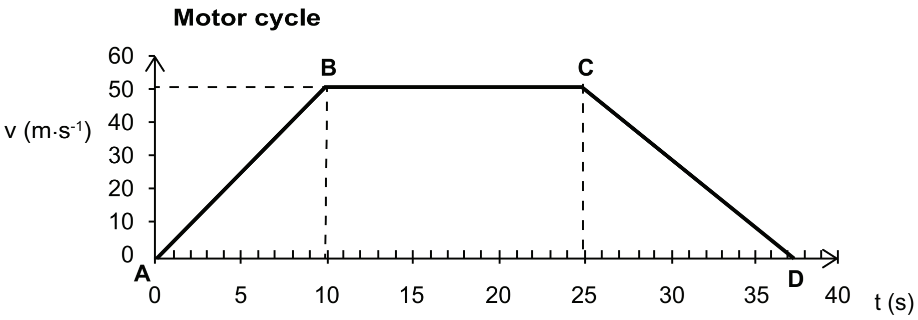
7. Which of the following statements is TRUE when a body moves in a straight line from rest with uniform acceleration?

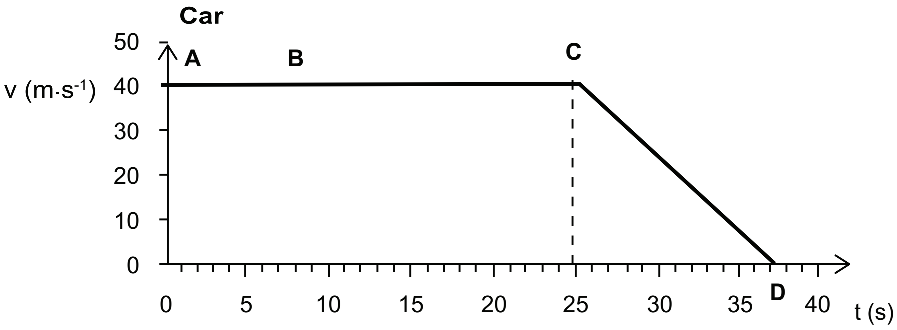
   I Its velocity increases by equal amounts in equal time intervals.
   II It travels equal distances in equal time intervals.
   III The distance travelled is directly proportional to the square of the time taken.

   A I only
   B III only
   C I and II only
   D I and III only (2)

LONG QUESTIONS

8. A car goes through a speed trap while it is travelling along a straight horizontal road. At the exact instant that the car passes the speed trap, a traffic officer sitting on her motorcycle at the side of the road sets off from rest to catch up with the car. When she catches up with the car, the officer orders the driver to stop and the driver immediately slows down and stops the car.





The graphs above show the motion of the motor cycle and the car from the moment when the car passes through the speed trap.

8.1 Describe the motion (no displacements needed) of the motor cycle from A to D. (3)

8.2 Using the graph, calculate the magnitude of the acceleration of the motor cycle from A to B. (3)

8.3 Using an equation of motion, calculate the acceleration of the motor cycle from C to D. (4)

8.4 Draw an acceleration-time graph for the motion of the motor cycle from A to D. (5)

8.5 Use the car's graph to determine how far from the speed trap the car stopped. (4)

8.6 The speed limit on the road is 120 $km \cdot h^{-1}$. By how much was the car exceeding the speed limit? (3)

8.7 The fine for exceeding the speed limit is R25,00 per $km \cdot h^{-1}$ over the limit. How much did the traffic officer fine the driver of the car? (2)

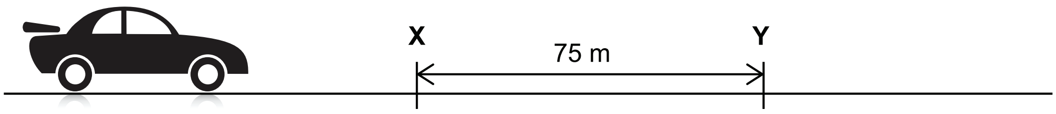
8.8 Draw a position-time graph for the motion of the car from A to D. (4)

9. The speed of a car between two sets of traffic lights changes is shown in the table below.

Time (s)	0	20	40	60	80	100	120
Speed ($m{\cdot}s^{-1}$)	0,0	2,5	5,0	7,5	10,0	5,0	0,0

9.1 On a piece of graph paper, plot a speed-time graph of the car's motion. (6)
9.2 Determine the acceleration of the car over the first 40 s. (4)
9.3 Determine the acceleration of the car over the last 20 s. (4)
9.4 How far (in m) did the car travel during these 2 minutes? (4)

10. In a test drive on a dry road, the driver was instructed to travel at 30 $m{\cdot}s^{-1}$ and to apply the brakes to stop the car when he passed a roadside marker X. The car stopped 75 m beyond X. The point where the car stopped was labelled Y.

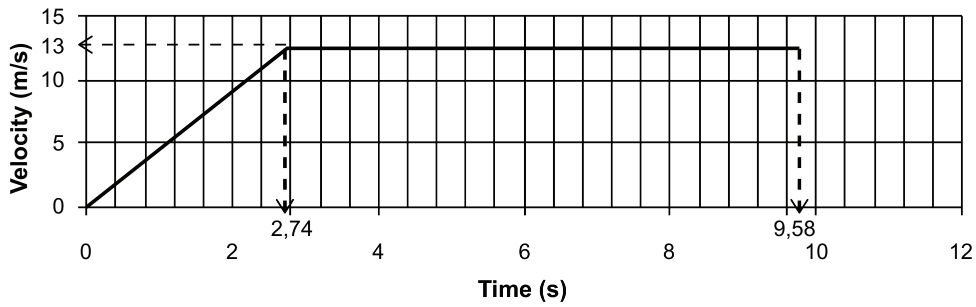


10.1 What was the average speed of the car between X and Y? (3)
10.2 How long (in s) did it take for the car to stop? (3)
10.3 Calculate the car's acceleration. (4)
10.4 This test was done on a dry road surface. **How** would magnitude of the acceleration differ on a wet road? (1)
10.5 **Why** would the magnitude of the acceleration differ? Explain briefly. (3)

11. The **100 metres**, or **100-metre dash**, is a sprint race in track and field competitions. The reigning 100 m Olympic champion is often named "the fastest man/woman in the world". On 16 August 2009, Usain Bolt (Jamaica), set a new world record for the men's 100 m in Berlin. He completed the race in 9,58 s.

[Source: Wikipedia (08 October 2011)]

The following velocity-time graph is a simplified representation of Usain's motion over the duration of the race:

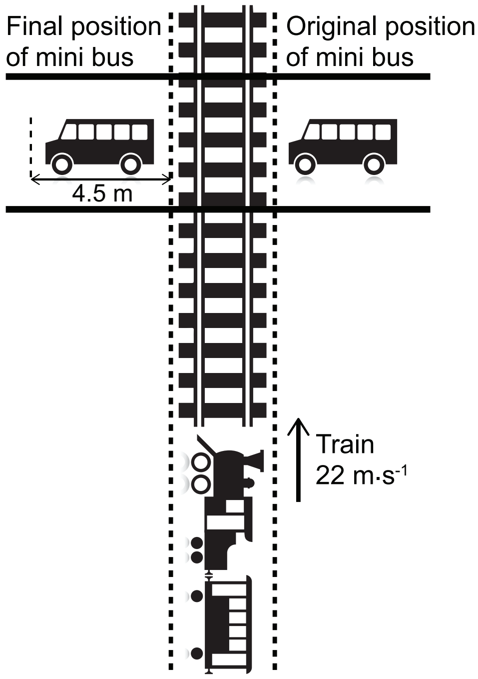


11.1 Determine Usain Bolt's acceleration over the first 2,74 s. (4)
11.2 Use the graph to determine how far he ran during the first 2,74 s. (4)
11.3 Use an equation of motion to confirm your answer in 11.2. (4)
11.4 Give two reasons why we can use equations of motion to calculate values in this question. (2)

12. A car accelerates uniformly at 3,5 m·s^{-1} from a speed of 10 m·s^{-1} for 5 s along a straight horizontal road.
    12.1 Define *uniform acceleration.* (3)
    12.2 Calculate the velocity of the car at 5 s. (4)
    12.3 Calculate how far the car travelled in 5 s. (4)

13. The driver of a car travelling at 30 m·s^{-1} along a straight road brakes suddenly to a stop to avoid hitting a cow that is standing in the road. It takes him 3 s from the time he sees the cow to the time when he applies the brakes. These 3 s are called the "reaction time". He slows down at a rate of 4 m·s^{-2}.
    13.1 What distance does the car cover during the 3 s of reaction time? (3)
    13.2 What distance does the car cover during the time when the brakes are applied? (4)
    13.3 Draw a neat velocity – time graph of the car's motion from the time the driver first saw the cow to the time that the car was brought to a stop. If necessary calculate any relevant values which you need to draw this graph. (7)

14. A train travels at a constant velocity of 22 m·s^{-1} along a straight railway track towards a level crossing. A mini bus, which is 4,5 m long, is stationary at the level crossing. The mini bus driver decides to cross the track. The mini bus is capable of accelerating at 2 m·s^{-2} and the width of the track is 2,5 m.



    14.1 Calculate the shortest time it takes the mini bus to cross the railway track. (4)
    14.2 How far away must the train be if the mini bus is to cross the track in front of the train without colliding with it? Assume the train maintains a constant velocity. (4)

MARKING GUIDELINES

MULTIPLE CHOICE

1. A✓ ✓ Acceleration is the rate of change of velocity. When acceleration is constant, the rate of change of velocity is constant. [CL 2] (2)

2. D✓ ✓ The velocity increases. Acceleration is constant (acceleration due to gravity remains constant). [CL 3] (2)

3. B✓ ✓ The area under a speed – time graph represents distance; the area under a velocity – time graph represents displacement. [CL 3] (2)

4. C✓ ✓ Acceleration is represented by the gradient of a velocity – time graph because $a = \frac{\Delta v}{\Delta t}$ [CL 2] (2)

5. B✓ ✓ When the object approaches you it starts off far away from you (at a greater position). Its position decreases until when it is at position = 0 m, it is beside you. The only possible choices are B and D. But the object moves towards you with a constant velocity, therefore the graph will be a straight-line graph (since the gradient (velocity) remains constant). [CL 3] (2)

6. D✓ ✓ When the velocity is constant, the magnitude of the velocity is constant, and the direction is constant. The magnitude of the velocity is equal to the speed because the distance has the same magnitude as the displacement. [CL 2] (2)

7. D✓ ✓ At constant acceleration, the velocity increases by the same constant amount in each second. Since the object accelerates from rest, its initial velocity is 0 m·s^{-1}.

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = \frac{1}{2} a \Delta t^2$$

Therefore, displacement is directly proportional to the square of time. [CL 3] (2)

LONG QUESTIONS

8. 8.1 A to B: Constant (uniform) acceleration (from rest to 50 m·s^{-1}) ✓
B to C: Constant (uniform) velocity (of 50 m·s^{-1}) ✓
C to D: Constant (negative) acceleration (from 50 m·s^{-1} to rest) ✓
OR slowing down at a constant rate
OR constant deceleration. [CL2] (3)

ASSESSMENTS

8.2 a = gradient of the graph OR $\frac{\Delta y}{\Delta x}$ OR $\frac{\Delta v}{\Delta t}$ ✓ (method)

$= \frac{50 - 0}{10 - 0}$ ✓ (substitutions)

$= 5\ \text{m·s}^{-2}$ ✓ (accuracy; SI units) [CL2] (3)

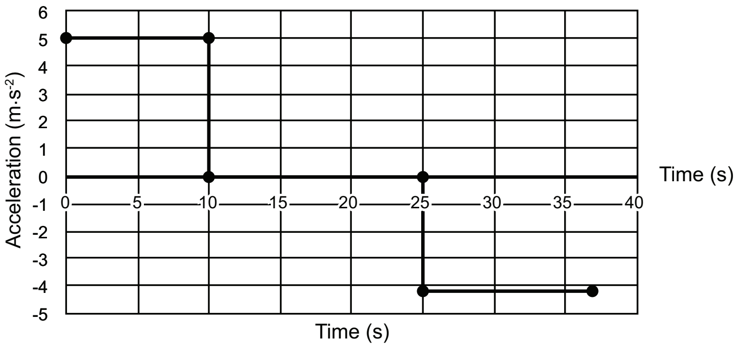
8.3 $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{0 - 50}{37 - 25}$ ✓ (substitutions)

$= -4,17\ \text{m·s}^{-2}$ ✓ (accuracy; SI units)

$= 4,17\ \text{m·s}^{-2}$ backwards (in the opposite direction) ✓ (direction) [CL3] (4)

8.4



✓ y-axis
✓ x-axis
✓ 0-10 s
✓ 10 – 25 s
✓ 25 – 37 s

[CL3] (5)

8.5 Δx = area under v-t graph ✓ (method)

$= (25 \times 40)$ ✓ $+ \frac{1}{2}(37 - 25) \times 50$ ✓ (substitutions)

$= 1300\ \text{m}$ ✓ (accuracy; SI units)

[CL3](4)

8.6 $50\ \text{m·s}^{-1} = \frac{50 \times 60 \times 60}{1\,000}$ ✓ (method)

$= 180\ \text{km·h}^{-1}$ ✓ (accuracy)

Car exceeds speed limit by $180 - 120 = 60\ \text{km.h}^{-1}$ ✓ (accuracy; SI units)

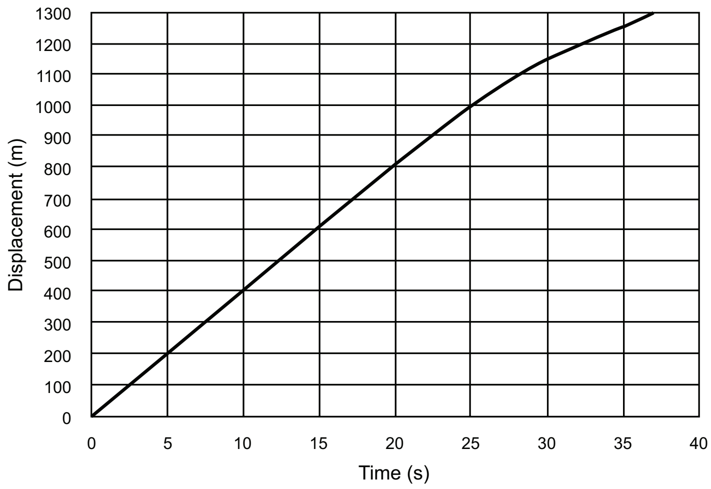
[CL2](3)

8.7 Fine $= 60 \times \text{R}25.00$ ✓ (method; c.o.e.)

$= \text{R}1500$ ✓ (accuracy; units)

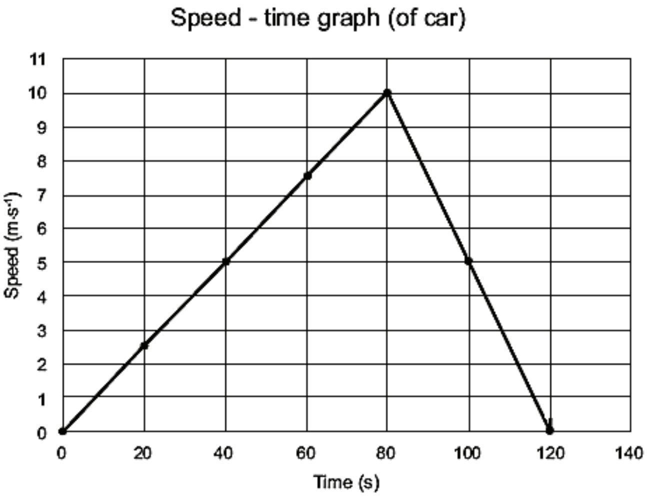
[CL2] (2)

8.8



✓ Vertical axis: shows 0, 1 000 and 1 300 (c.o.e.)
✓ Horizontal axis: shows 0, 25, and 37
✓ Straight line from 0 to 25 s
✓ Parabola curving down (as shown) [CL4] (4)

9. 9.1



✓ Title ✓ ✓ Axes titles and scales
✓ Points plotted accurately ✓ ✓ Two straight lines [CL2] (6)

9.2 $a = \frac{\Delta v}{\Delta t}$ OR $\frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{5 - 0}{40}$ ✓ (substitutions)

$= 0,125 (0,13)\ m{\cdot}s^{-2}$ ✓ (accuracy; SI units)

forward ✓ (direction) [CL2] (4)

9.3 $a = \frac{\Delta v}{\Delta t}$ OR $\frac{v_f - v_i}{\Delta t}$
$= \frac{5 - 10 ✓}{20 ✓}$ (substitutions)
$= -0{,}25$ ✓ (accuracy)
$0{,}25\ m{\cdot}s^{-2}$ backward✓ (SI units; direction) [CL3] (4)

9.4 Distance = area under speed – time graph ✓ (method)
$= \frac{1}{2} \times 80 \times 10$ ✓ $+ \frac{1}{2} \times 20 \times 10$ ✓ (substitutions)
= 500 m ✓ (accuracy; SI units) [CL2] (4)

10. 10.1 Average speed $= \frac{1}{2}(v_f + v_i)$✓ (method)
$= \frac{1}{2}(30 + 0)$✓ (substitutions)
$= 15\ m{\cdot}s^{-1}$✓ (accuracy; SI units) [CL3] (3)

10.2 Average speed $= \frac{\text{distance}}{\text{time}}$ ✓ (method)
$15 = \frac{75}{\text{time}}$ ✓ (substitutions)
Time $= \frac{75}{15} = 5\ s$✓ (accuracy; SI units) [CL2] (3)

10.3 $v_f^2 = v_i^2 + 2a\Delta x$ ✓ (method)
$0 = (30)^2 + 2a(75)$✓ (substitutions)
$a = \frac{-900}{2 \times 75} = -6\ m{\cdot}s^{-2}$ ✓ (accuracy; SI units)
$6\ m{\cdot}s^{-2}$ backward✓ (direction) [CL2] (4)

10.4 It would decrease. ✓ [CL3] (1)

10.5 The road would be slippery. ✓
The time taken to stop the car would increase. ✓
Since $a = \frac{\Delta v}{\Delta t}$ ✓, (and the time has increased,) the magnitude of the acceleration decreases. [CL4] (3)

11. 11.1 $a = \frac{\Delta v}{\Delta t}$ OR $\frac{v_f - v_i}{\Delta t}$ ✓ (method)
$= \frac{13 - 0}{2{,}74}$ ✓ (substitutions)
$= 4{,}74\ m{\cdot}s^{-2}$ ✓ (accuracy; SI units)
forward ✓ (direction) [CL2] (4)

11.2 Distance = area under v-t graph ✓ (method)

$= \frac{1}{2}$✓ $(13 \times 2{,}74)$ ✓ (substitutions)

$= 17{,}81\,m$ ✓ (accuracy; SI units) [CL2] (4)

11.3 ALTERNATIVE 1

$\Delta x = \frac{1}{2}(v_i + v_f) \times \Delta t$ ✓ $= \frac{1}{2}(0 + 13)$ ✓ $\times 2{,}74$ ✓ $= 17{,}81\,m$ ✓

(method) (substitutions) (accuracy; SI units)

ALTERNATIVE 2

$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ $= 0 + \frac{1}{2}(4{,}74)$ ✓ $(2{,}74)^2$ ✓ $= 17{,}79\,m$ ✓

(method) (substitutions) (accuracy; SI units)

ALTERNATIVE 3

$v_f^2 = v_i^2 + 2a\Delta x$ ✓ (method)

$(13)^2$ ✓ $= 0 + 2(4{,}74)\Delta x$ ✓ (substitutions)

$\Delta x = 17{,}83\,m$ ✓ (accuracy; SI units)

The slight differences in the values of these answers are due to round up errors. These differences can be ignored. [CL2] (4)

11.4 The acceleration is uniform (constant). ✓
The motion takes place along a straight line. ✓ [CL3] (2)

12. 12.1 Uniform acceleration is the constant ✓ rate of change of velocity. ✓ ✓ [CL1] (3)

12.2 $v_f = v_i + a\Delta t$ ✓ (method)

$= 10 + 3{,}5 \times 5$ ✓ (substitutions)

$= 27{,}5\,m{\cdot}s^{-1}$ ✓ forwards ✓ (accuracy; SI units) (direction)

[CL2] (4)

12.3 $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ ✓ (method)

$= (10 \times 5)$ ✓ $+ \frac{1}{2}(3{,}5 \times (10)^2)$ ✓ (substitutions)

= 225 m ✓ (accuracy; SI units) [CL2] (4)

13. 13.1 Distance = average speed × time ✓ (method)

$= 30 \times 3$ ✓ (substitutions)

$= 90\,m$ ✓ (accuracy; SI units) [CL2] (3)

13.2 $v_f^2 = v_i^2 + 2a\Delta x$ ✓ (method)

$0 = (30)^2$ ✓ $+ 2(-4)\Delta x$ ✓ (substitutions)

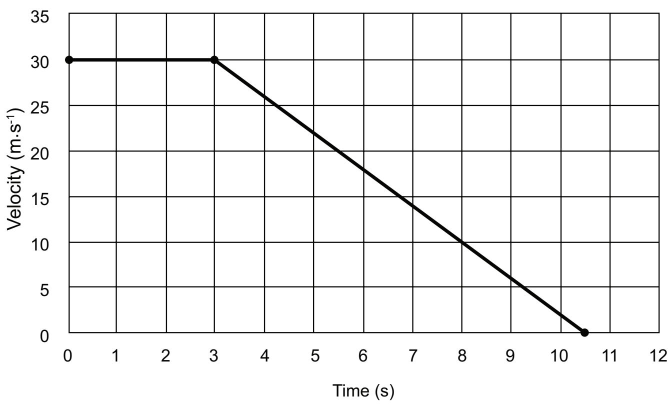
$\Delta x = 112{,}5\,m$ ✓ (accuracy; SI units) [CL2] (4)

ASSESSMENTS

13.3 $a = \frac{v_f - v_i}{\Delta t}$ ✓ (method)

$= \frac{0 - 30}{-4}$ ✓ (substitutions)

$= 7,5\ s$ ✓ (accuracy; SI units)



✓ y-axis: labels and scale

✓ x-axis: labels and scale (including 10,5 s)

✓ 0 – 3 s

✓ 3 – 10,5 s

[CL3] (7)

14. 14.1 The mini bus must move a minimum distance of $2,5 + 4,5\ m = 7\ m$ ✓

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ ✓ (method)

$7 = 0 + \frac{1}{2}(2)\Delta t^2$ ✓ (substitutions)

$\Delta t = \sqrt{7}$

$= 2,65\ s$ ✓ (accuracy; SI units) [CL3] (4)

14.2 $\text{Distance} = \text{average speed} \times \text{time}$ ✓ (method)

$= 22 \times 2,65$ ✓ (substitutions)

$= 58,3\ m$ ✓ (accuracy; SI units)

At least 58,3 m (more than 58,3 m) ✓ (interpretation of answer) [CL3] (4)