

# SENIOR SECONDARY IMPROVEMENT PROGRAMME 2013



## GRADE 12

## PHYSICAL SCIENCES

## LEARNER NOTES

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## LEARNER NOTES

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## SESSION 8

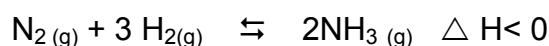
## TOPIC: CHEMICAL EQUILIBRIUM

**Learner Note:** Please understand and learn the factors affecting the rate of a reaction very well before attempting this section on chemical equilibrium. The only factors affecting chemical equilibrium are temperature, concentration and pressure.

## SECTION A: TYPICAL EXAM QUESTIONS

## QUESTION 1: 5 minutes

Consider the following equilibrium reaction:



9 mol of  $\text{N}_2$  and 15 mol of  $\text{H}_2$  are pumped into a  $500\text{cm}^3$  container at room temperature.

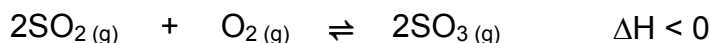
The temperature of the gas mixture is now raised to  $405^\circ\text{C}$  resulting in 8 mol  $\text{NH}_3$  being present at equilibrium.

Calculate the value of  $K_c$  at  $405^\circ\text{C}$

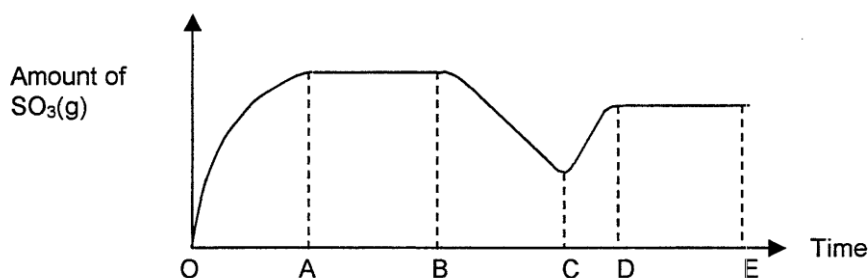
[6]

## QUESTION 2: 18 minutes

Consider the following reaction:



A graph of the AMOUNT of  $\text{SO}_3(\text{g})$  was plotted against time as shown below:



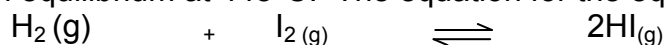
2.1 How does the rate of the forward reaction compare to the rate of the reverse reaction during the following intervals?: (Write down only GREATER THAN, EQUAL TO or LESS THAN.)

- 2.1.1 OA (1)
- 2.1.2 BC (1)
- 2.1.3 DE (1)

- 2.2 Initially 8,0 moles of  $\text{SO}_2(\text{g})$  and  $x$  moles of  $\text{O}_2(\text{g})$  are placed in a  $2,0 \text{ dm}^3$  empty container and sealed at a specific temperature. At equilibrium 6,0 moles of  $\text{SO}_3(\text{g})$  are present in the container. If the  $K_C$  value of the above equilibrium at this temperature is 9, calculate  $x$ , that is, the initial amount of  $\text{O}_2(\text{g})$  that was placed in the container. (6)
- 2.3 If the changes in the graph from B to D are due to changes in the TEMPERATURE, at which points (B, C or D) will the temperature be the lowest? (1)
- 2.4 Give an explanation for the answer to 2.3. (2)
- 2.5 At which point (B, C or D) will the  $K_C$  value be the greatest? (1)
- 2.6 Give an explanation for the answer to 2.5. (2)
- 2.7 If the changes in the graph from B to D are due to PRESSURE changes, at which point (B, C or D) will the pressure be the lowest? (1)
- 2.8 Give an explanation for the answer to 2.7. (2)
- [18]

**QUESTION 3: 7 minutes**

3. A mixture of 5 moles of  $\text{H}_2(\text{g})$  and 10 moles of  $\text{I}_2(\text{g})$  is placed in a  $5\text{dm}^3$  container and is allowed to reach equilibrium at  $448^\circ\text{C}$ . The equation for the equilibrium reaction is:



At equilibrium the concentration of the  $\text{HI}(\text{g})$  is equal to  $1,88 \text{ mol}\cdot\text{dm}^{-3}$ .

- 3.1 Calculate the value of  $K_C$  at  $448^\circ\text{C}$ . (6)
- 3.2 While the system is in equilibrium,  $\text{H}_2(\text{g})$  is added to it. Explain by using Le Chatelier's principle how the addition of  $\text{H}_2(\text{g})$  influences the number of moles of  $\text{HI}(\text{g})$  when a new equilibrium has been established. Assume that the temperature is kept constant (3)
- [9]

**QUESTION 4: 20 minutes**

(Physical Sciences Paper 2 DoE Feb – March 2010)

Combustion in air at high temperatures produces oxides of nitrogen of which nitrogen dioxide ( $\text{NO}_2(\text{g})$ ), is the most common. Natural sources of nitrogen dioxide include lightning and the activity of some soil bacteria. These natural sources are small compared to emissions caused by human activity.

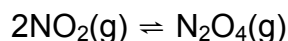
$\text{NO}_2$  can irritate the lungs and cause respiratory infection. When  $\text{NO}_2(\text{g})$  dissolves in rainwater in air it forms nitric acid which contributes to acid rain.

- 4.1 State TWO human activities that contribute to high nitrogen dioxide levels in the atmosphere. (2)
- 4.2 Write a balanced equation to show how nitric acid forms from nitrogen dioxide in air. (2)

4.3 High levels of nitrogen dioxide in the atmosphere can result in damage to crops and eventually food shortages. Briefly state how high levels of nitrogen dioxide can damage crops. (1)

4.4 Nitric acid can cause corrosion of copper cables whilst hydrochloric acid does no harm to copper cables. Refer to the relative strengths of the oxidising agents involved to explain this phenomenon (3)

4.5 2 mol of  $\text{NO}_2(\text{g})$  and an unknown amount of  $\text{N}_2\text{O}_4(\text{g})$  are sealed in a  $2 \text{ dm}^3$  container, that is fitted with a plunger, at a certain temperature. The following reaction takes place:



At equilibrium it is found that the  $\text{NO}_2$  concentration is  $0,4 \text{ mol}\cdot\text{dm}^{-3}$ .

The equilibrium constant at this temperature is 2.

4.5.1 Calculate the initial amount (in mol) of  $\text{N}_2\text{O}_4(\text{g})$  that was sealed in the container. (9)

The plunger is now pushed into the container causing the pressure of the enclosed gas to increase by decreasing the volume.

4.5.2 How will this change influence the amount of nitrogen dioxide at equilibrium? Only write down INCREASES, DECREASES or REMAINS THE SAME. (1)

4.5.3 Use Le Chatelier's principle to explain your answer to QUESTION 4.5.2. (2)  
[21]

**SECTION B: ADDITIONAL CONTENT NOTES****EQUILIBRIUM****EFFECTIVENESS OF REACTIONS****What is equilibrium?**



- ⇌ Reactions that take place in both the forward and reverse directions simultaneously are called reversible reactions.
- ⇌ Observable macroscopic changes stop, while microscopic changes continue as reactants change to products, and products change back into reactants.
- ⇌ When the rate of the forward reaction equals the rate of the reverse reaction, we say a state of dynamic equilibrium has been reached.

**Le Chatelier's Principle**




If the conditions of an equilibrium system are changed by changing temperature, pressure or concentration, a process takes place which tends to oppose the effect of the change.

- ⇌ An equilibrium may be disturbed by changing any one (or more) of the factors for the equilibrium.
  - Temperature
  - Concentration (gases and solutions)
  - Pressure (gases only)




**Changing Equilibrium Conditions****Concentration**

-  An increase in concentration of any reactant will cause an increase in the reaction rate of the forward reaction.
-  Increasing the concentration of the  $\text{N}_2$  or  $\text{H}_2$  would, therefore, increase the rate of the forward reaction, hence favouring the shift of the equilibrium towards the forward reaction.



**Temperature**

-  An increase in temperature causes an increase in the rate of **both** reactions.
-   $\Delta H$  refers to the forward reaction. If it is negative, the reaction is exothermic (energy is liberated).
-  Increasing the temperature will favour the endothermic (reverse) reaction.

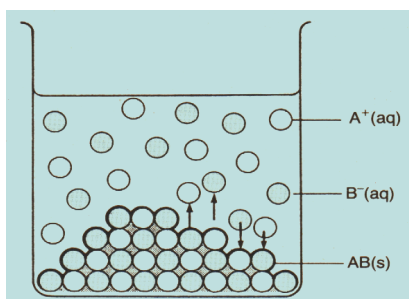
## Pressure

-  Pressure can be increased by decreasing the volume of the container.
-  When the volume of the container decreases, the total concentration of all gases increases.
-  According to Le Chatelier, the reaction that will decrease the total number of gas moles in the space will be favoured. (favours side with lowest number of gas moles)

### So to ensure maximum yield of ammonia:

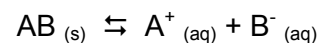
-  Use catalyst to reach equilibrium quickly.
-  Once equilibrium is reached:
  - Drop temperature to 450 °C
  - Increase conc. of N<sub>2</sub> & H<sub>2</sub> & decrease conc. of NH<sub>3</sub>
  - Increase pressure in container by reducing volume.

## Equilibrium in solutions



The equation for the equilibrium reaction of a saturated salt solution can be represented as follows:

$$K_{sp} = [A^+][B^-]$$



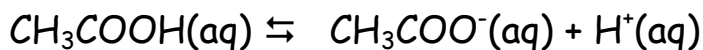
- \* Adding HCl (H<sup>+</sup> and Cl<sup>-</sup> ions) to the above<sup>22</sup> solution in equilibrium causes the equilibrium to favour the reverse reaction to compensate for the additional Cl<sup>-</sup> ions that were added to the product side.
- \* NaCl is, therefore, precipitated until the equilibrium is restored. More white solid is formed
- \* Shifting the equilibrium of a salt in a solution by increasing the concentration of one kind of ion is called the *common ion effect*.

## Equilibrium in acids

☺ When the acid is strong, the equilibrium lies far to the product side (lots of ions form).

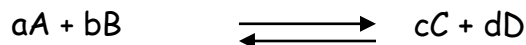


☺ When the acid is weak, the equilibrium lies far to the reactant side (few ions form).



## Equilibrium Constant

If we look at the following GENERAL equation



The expression for the Equilibrium constant –  $K_c$  will be as follows:

$$K_c = \frac{[\text{C}]^c [\text{D}]^d}{[\text{A}]^a [\text{B}]^b}$$

If A, B, C or D are solids or pure liquids, they must be LEFT OUT of the  $K_c$  expression.

- ⇌ When  $K_c$  has a high value, there will be proportionally more of the substance on the product side - we say the equilibrium *lies to the product side* (vice versa for a low value).
- ⇌ **Only temperature** alters the  $K_c$  value for a specific reaction
- ⇌ If pressure or concentration are changed, the system adjusts the product and reactant concentrations in such a way that  $K_c$  stays exactly the same (on condition the temperature does NOT change)

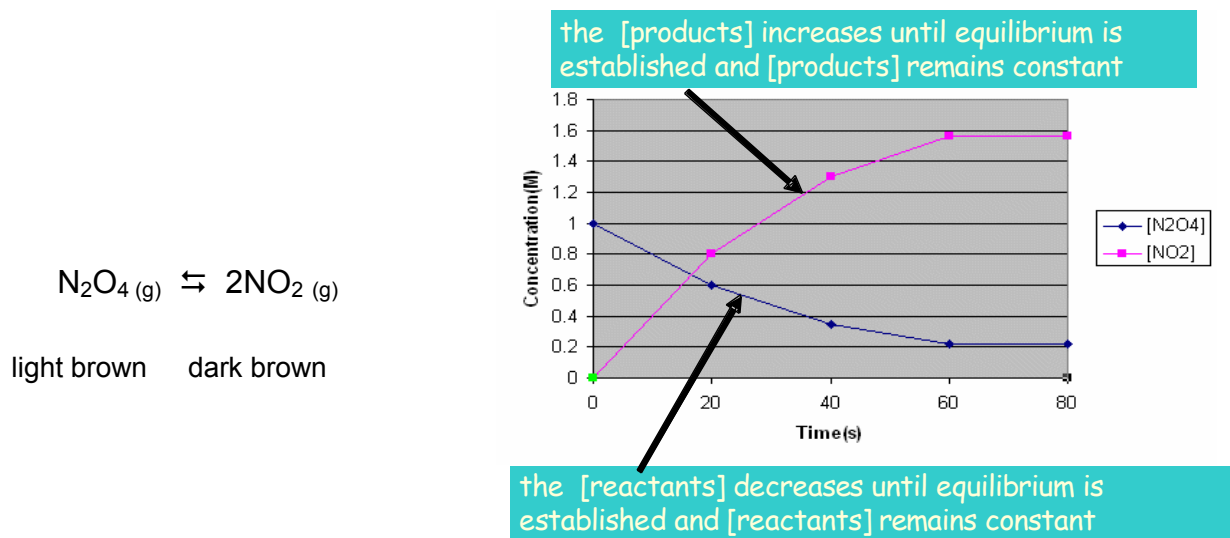
## Graph examples

Comparing reaction rates of the forward and reverse reactions

- ✗ [A] (square brackets mean concentration of A) and [B] initially decrease.
- ✗ [C] and [D] initially increase.
- ✗ The rate of the forward reaction becomes constant and becomes equal to the rate of the reverse reaction.
- ✗ At this point (equilibrium) the concentrations of reactants and products remain constant.



Comparing concentrations of products and reactants graphically.

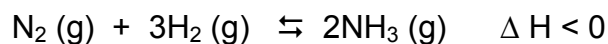


- ⊙ If I were to increase the temperature, more NO<sub>2</sub> to form.
- ⊙ This suggests that the forward reaction must be endothermic. ( $\Delta H > 0$ )
- ⊙ Also increasing pressure favours side with least gas moles (reactants) therefore reverse reaction (1 mole as opposed to 2 moles of gas) is favoured.

## SECTION C: HOMEWORK

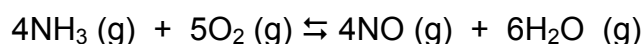
**QUESTION 1:**      **17 minutes** (Taken from DoE Physical Sciences Paper 2 Exemplar 2008)

- 1.1 Many industries use ammonia as a coolant in their plants. Ammonia is also used in the fertiliser industry. The ammonia is manufactured by the Haber process in the presence of a catalyst at a temperature of 500°C. The equilibrium process may be represented by the equation below:



The temperature is now decreased to 100°C. Explain whether or not the ammonia can now be produced profitably. (3)

- 1.2 Ammonia is used in the industrial preparation of nitric acid. One of the reactions in this process, shown below, reached equilibrium in a closed container at a temperature of 1 000 °C.



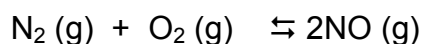
The initial concentrations of NH<sub>3</sub>(g) and O<sub>2</sub>(g) were both equal to 1 mol·dm<sup>-3</sup>. At equilibrium it is found that the concentration of NH<sub>3</sub>(g) has changed by 0,25 mol·dm<sup>-3</sup>.

1.2.1 Calculate the value of the equilibrium constant at the given temperature. (9)

1.2.2 Is the yield of NO high or low at this temperature? Give a reason for your answer (3)  
[15]

**QUESTION 2:** 8 minutes (Taken from DoE Physical Science Paper 2 November 2004)

- 7 Mol of nitrogen gas and 2 mol of oxygen gas are placed in an empty container of volume  $2 \text{ dm}^3$ . The container is sealed and the following equilibrium is established:



At equilibrium, there is 0,4 mol NO (g) present. Determine the value of  $K_c$  at this temperature.

[6]

**SECTION D: SOLUTIONS AND HINTS TO SECTION A**

**QUESTION 1**

	$\text{N}_2$	$\text{H}_2$	$\text{NH}_3$
Initial number of mole (mol)	9	15	0
Number of moles used/formed (mol)	4	12	8
Number of moles at equilibrium (mol)	5	3	8
Equilibrium concentration ( $\text{mol} \cdot \text{dm}^{-3}$ ) $c = n/V$	$10\sqrt{\phantom{x}}$	$6\sqrt{\phantom{x}}$	$16\sqrt{\phantom{x}}$

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \sqrt{\phantom{x}}$$

$$= \frac{16^2}{(10)(6)^3} \sqrt{\phantom{x}}$$

$$= 0,12 \sqrt{\phantom{x}}$$

[6]

**QUESTION 2**

2.1.1. greater than  $\sqrt{\phantom{x}}$  (1)

2.1.2. less than  $\sqrt{\phantom{x}}$  (1)

2.1.3. equal to  $\sqrt{\phantom{x}}$  (1)

2.2.

	SO <sub>2</sub>	O <sub>2</sub>	SO <sub>3</sub>
Initial number of mole (mol)	8	x	0
Number of moles used/formed (mol)	6	3	6
Number of moles at equilibrium (mol)	2	x - 3	6
Equilibrium concentration (mol·dm <sup>-3</sup> ) c = n/V	1√	$\frac{x-3}{2}$ √	3√

$$K_c = \frac{[\text{SO}_3]^2}{[\text{O}_2][\text{SO}_2]^2} \sqrt{\phantom{x}}$$

$$9 = \frac{3^2}{\frac{(x-3)(1)^2}{2}} \sqrt{\phantom{x}}$$

$$x = 5 \text{ mol } \sqrt{\phantom{x}} \quad (6)$$

2.3. B√ (1)

2.4. Forward is exo. √ Exo is favoured at colder temperatures√ (2)

2.5. B√ (1)

2.6. More product √therefore larger K<sub>c</sub>√ (2)

2.7. C√ (1)

2.8. Low pressure favours reverse reaction √since more gas moles are at reactants side√ (2)

**[18]****QUESTION 3**

3.1

	H <sub>2</sub>	I <sub>2</sub>	HI
Initial number of mole (mol)	5	10	0
Number of moles used/formed (mol)	4,7	4,7	9,4
Number of moles at equilibrium (mol)	0,3	5,3	9,4√
Equilibrium concentration (mol·dm <sup>-3</sup> ) c = n/V	0,06√	1,06√	1,88

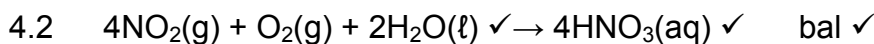
$$\begin{aligned}
 K_c &= \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} \checkmark \\
 &= \frac{(1,88)^2}{(0,06)(1,06)} \checkmark \\
 &= 55,57 \checkmark \qquad (6)
 \end{aligned}$$

3.2. An increase in  $\text{H}_2$  will according to Le Chatelier's Principle cause the equilibrium to shift so as to decrease the  $\text{H}_2$  by forming more product.  $\checkmark$  This favours the forward reaction.  $\checkmark$  In addition an increase in  $\text{H}_2$  increases the pressure which will also favour the forward reaction to produce lower moles of gas.  $\checkmark$  (3)  
[9]

#### QUESTION 4

4.1 Any two

- Burning of fuel when cars are used - exhaust gases contains oxides of nitrogen.  $\checkmark$
- Burning of coal (generation of electricity)/nitrogen containing compounds/organic waste.  $\checkmark$
- Factories and other industrial plants that emits nitrogen oxides into the atmosphere as waste. (2)



OR



4.3  $\text{NO}_2(\text{g})$  dissolves in rainwater to form acid rain that burns/destroys crops.  $\checkmark$  (1)

4.4  $\text{NO}_3^-(\text{aq})$  is a strong oxidising agent  $\checkmark$

and oxidise Cu (to  $\text{Cu}^{2+}$ ).  $\checkmark$

$\text{H}^+(\text{aq})$  is not a strong enough oxidising agent  $\checkmark$  and cannot oxidise Cu to  $\text{Cu}^{2+}$ . (3)

## 4.5.1

	2NO <sub>2</sub>	N <sub>2</sub> O <sub>4</sub>
Initial number of mole (mol)	2	x
Number of moles used/formed (mol)	-1,2✓	+0,6 ✓
Number of moles at equilibrium(mol)	0,8✓	x + 0,6 ✓
Equilibrium concentration (mol·dm <sup>-3</sup> )	0,4	$\frac{x + 0,6}{2}$ ✓

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} \checkmark \therefore 2 \checkmark = \frac{\left(\frac{x + 0,6}{2}\right) \checkmark}{(0,4)^2} \checkmark \therefore x = 0,04 \text{ mol} \cdot \checkmark \quad (9)$$

← ( + )

4.5.2 Decreases ✓ (1)

4.5.3 Expressions with the same meaning as "forward reaction is favoured  
Equilibrium position shifts to the right. / Equilibrium lies to the right

**Accept: the equilibrium shift to the right** (2)

**[21]**

## SESSION 9

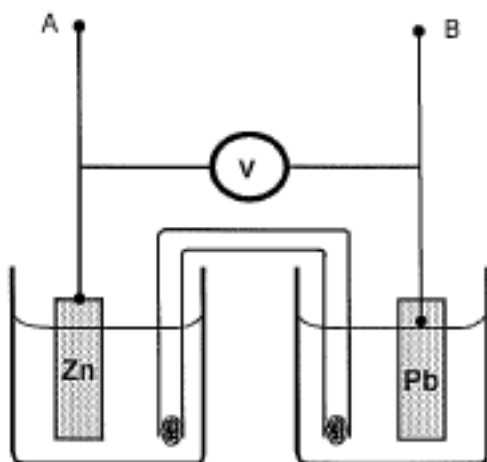
## TOPIC: ELECTROLYTIC AND GALVANIC CELLS

## SECTION A: TYPICAL EXAM QUESTIONS

## QUESTION 1: 25 minutes

(Taken from DoE Physical Sciences Preparatory Examination Paper 2 2008)

Tina wants to investigate the effect of the area of the metal plates used as electrodes in a galvanic cell on the emf of the cell. She sets up the following Zn/Pb cell under standard conditions and measures the emf.



- 1.1 Which electrode will show an increase in mass when this cell is functioning? (1)
- 1.2 Write down the equation for the half-reaction occurring at the anode. (2)
- 1.3 Calculate the emf that you would expect Tina to read on the voltmeter. (4)
- 1.4 Name two variables that should be controlled during this investigation. (2)
- 1.5 Write down the overall nett ionic equation. (3)
- 1.6 Write down the cell notation for the reaction. (3)
- 1.7 Tina now replaces the two metal plates with ones of a larger surface area, and takes the reading again.
  - 1.7.1 How would you expect the new emf to compare with the one calculated in Question 1.3? (Write only smaller than, larger than or equal to.) (1)
  - 1.7.2 Explain your answer to question 1.7.1. (2)
- 1.8 Tina now connects a resistor of low resistance across the terminals A and B. She notes that the reading on the voltmeter immediately drops.
  - 1.8.1 Give a reason for this observation. (2)
  - 1.8.2 After some time she observes a further gradual drop in the reading on the voltmeter.
  - 1.8.3 Give a reason for this observation. (2)

[22]

**QUESTION 2: 15 minutes**

(Taken from DoE Physical Sciences November Examination Paper 2 2010)

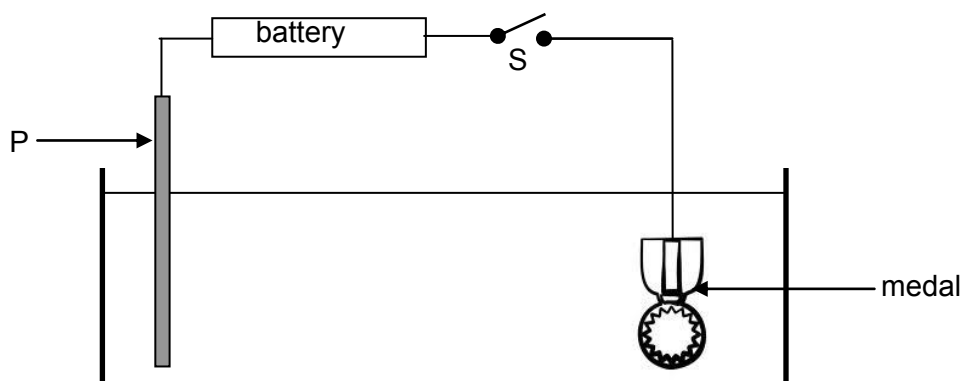
The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode **X** is shown below.



- 2.1 Name the component of the cell represented by the double vertical lines (||) in the above cell notation. (1)
- 2.2 State the TWO standard conditions that are applicable to the  $Pb^{2+}|Pb$  half-cell. (2)
- 2.3 Identify the oxidising agent in the above cell. (1)
- 2.4 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal **X** by calculating the standard reduction potential of the unknown metal **X**. (5)
- 2.5 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. (3)
- 2.6 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the  $X(s)|X^{3+}(aq)$  half-cell is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. (2)
- 2.7 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. (2)
- [16]

**QUESTION 3: 15 minutes**

The diagram below represents a cell that can be used to electroplate a tin medal with a thin layer of silver to improve its appearance.



- 3.1 Which one of **P** or the **MEDAL** is the anode in this cell? (1)
- 3.2 Write down the following
- 3.2.1 NAME or SYMBOL of the element of which electrode **P** is composed (1)
- 3.2.2 NAME or FORMULA of the electrolyte that has to be used to achieve the desired results (1)
- 3.3 Switch **S** is now closed. Write down the visible changes that will occur at the following:
- 3.3.1 Electrode **P** (1)
- 3.3.2 The medal (1)
- 3.4 Write down the equation for the half-reaction to support the answer to QUESTION 3.3.2 (2)
- 3.5 How will the concentration of the electrolyte change during the electroplating process? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
- 3.6 You want to coat the medal with copper instead of silver. State TWO changes that you will make to the above cell to obtain a medal coated with copper (2)
- [10]

## SECTION B: ADDITIONAL CONTENT NOTES

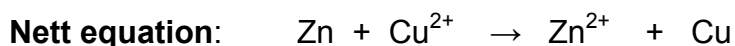
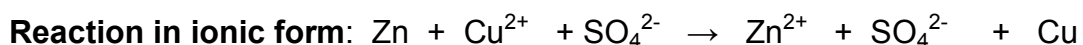
### REVISION OF GRADE 11 WORK

#### DIRECT TRANSFER OF ELECTRONS



*Blue*                      *clear*                      *brown*

**Observations:** *a small Zn plate placed in a blue copper sulphate solution gets covered with a brown precipitate of copper and, eventually, the solution turns clear, and the clear solution is zinc sulphate.*



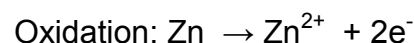
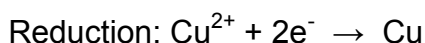
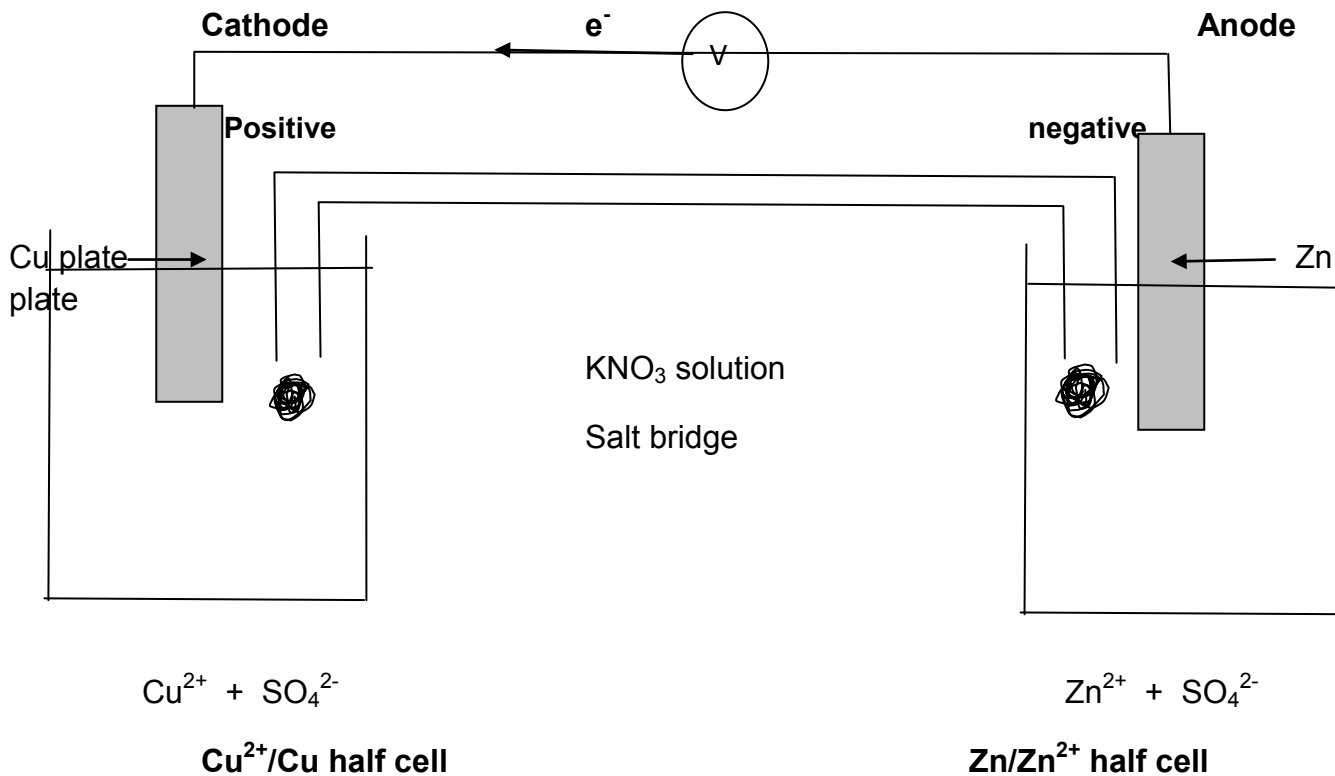


## INDIRECT TRANSFER OF ELECTRONS IN ELECTROCHEMICAL CELLS i.e. THE VOLTAIC OR GALVANIC CELL

Consider the Zn/Cu Cell:

Oxidation and reduction half-reactions take place in separate beakers - these are half-cells. Chemical energy is converted into electrical energy. An indirect transfer of electrons occurs as the electrons flow through the wire **from the anode to the cathode**.

- The salt bridge completes the circuit and ensures electrical neutrality of the electrochemical cell.



Complete Cell Notation:  $\text{Zn(s)} / \text{Zn}^{2+}(\text{1mol}\cdot\text{dm}^{-3}) // \text{Cu}^{2+}(\text{1mol}\cdot\text{dm}^{-3}) / \text{Cu(s)}$

### STANDARD ELECTRODE POTENTIALS: THE TABLE

- The Table gives standard Emf values and these values were all measured under standard conditions.
- A reference electrode (standard hydrogen half-cell) was chosen, and all values are measured relative to this.

**Using the Redox Table to write balanced equations:**

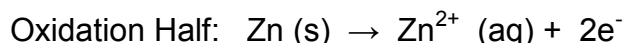
From **RIGHT** to **LEFT** is **OXIDATION** and from **LEFT** to **RIGHT** is **REDUCTION**.

- Consider the Zn/Cu cell.
- The reactions appear as follows in the Redox Table:

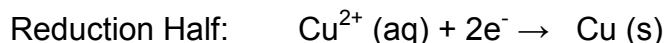
Half-reaction	$E^{\circ}$ /volt
$\text{Zn}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Zn}$	-0,76 V
$\text{Cu}^{2+} + 2\text{e}^{-} \rightleftharpoons \text{Cu}$	+0,34 V

- The reactant, i.e. Zn, is a **strong reducing agent**, i.e. gets oxidised.
- The reactant, i.e.  $\text{Cu}^{2+}$ , is a **strong oxidising agent** i.e. gets reduced.

**STEP 1:** The Top Reaction is written in the oxidation format, i.e. from right to left:



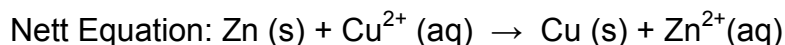
**STEP 2:** The Bottom Reaction is written in the reduction format, i.e., as it is, from left to right:



**STEP 3:** Balance the number of electrons by multiplying the whole concerned half-equation to make sure that the number of electrons are the same on both equations.

In the Zn/Cu cell the number of electrons is the same, so no need to multiply.

**STEP 4:** Cancel the electrons and then write the nett equation:

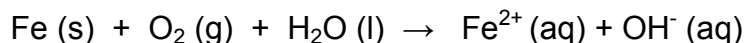
**ELECTROLYTIC CELLS**

This cell supports the non-spontaneous endothermic reaction. Energy is supplied by a battery and electrical energy is converted into chemical energy. In the electrolytic cell, oxidation occurs at the anode but the **anode** is the **POSITIVE** electrode. Reduction occurs at the cathode but the **cathode** is the **NEGATIVE** electrode. The  $E^{\circ}_{\text{cell}}$  can be calculated using the reduction tables but the answer will be negative. Electrolysis is the decomposition of a substance by passing an electric current through the electrolyte. Both electrodes are in the same electrolyte solution.

<b>SECTION C: HOMEWORK</b>
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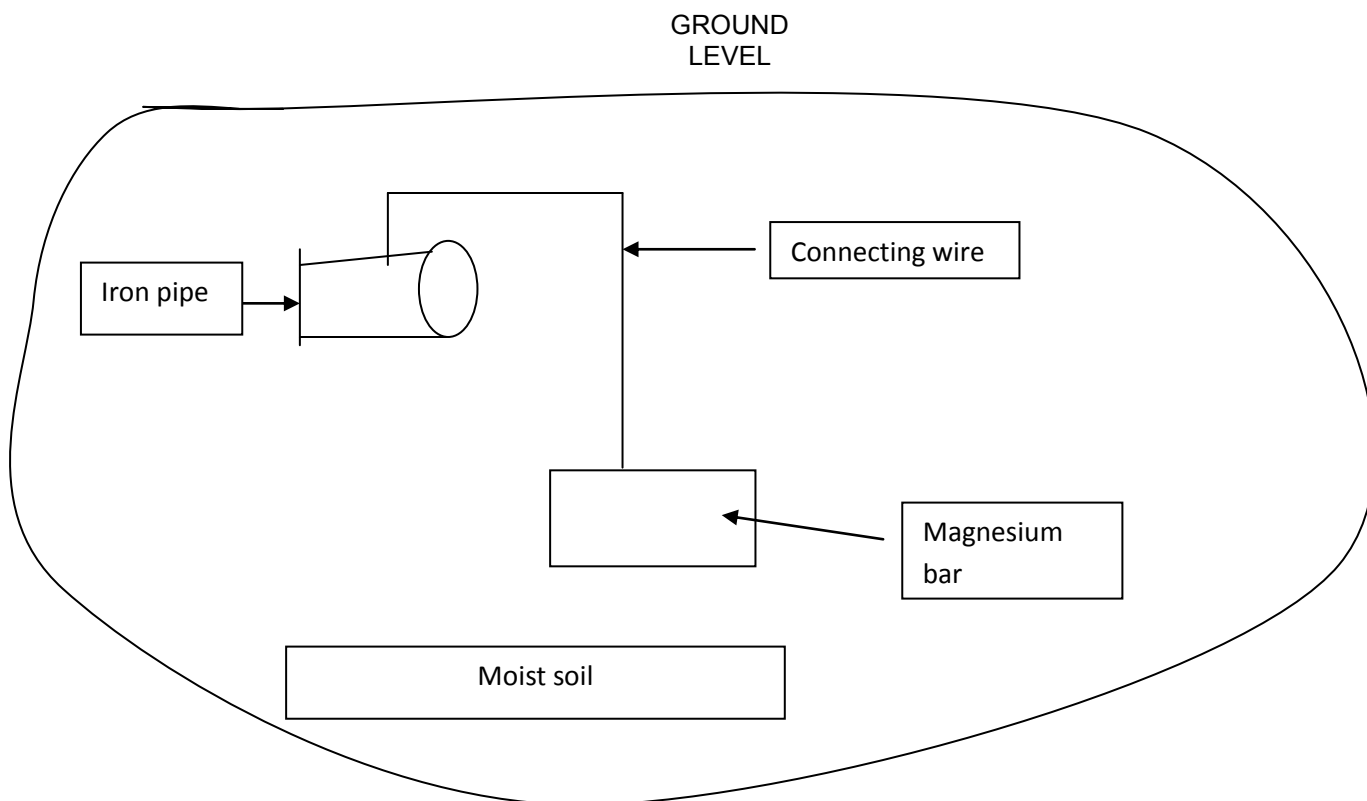
**QUESTION 1:**      **25 minutes** (Taken from DoE Physical Sciences Paper 2 November 2008)

- 1.1 Rusting is an unwanted redox reaction. Iron rusts when exposed to oxygen and moisture. The unbalanced ionic equation for one reaction that occurs during rusting, is represented below:



Use the table of Standard Reduction Potentials (Table 4A or 4B) to answer the following questions for this reaction:

- 1.1.1 Write down the oxidation half-reaction. (2)
- 1.1.2 Write down the NAME of the substance that is reduced. (1)
- 1.1.3 Perform a calculation to verify that this reaction is spontaneous. (5)
- 1.2 Magnesium is used to protect underground iron pipes against rusting. The diagram below shows an iron pipe connected to a magnesium bar.



- 1.2.1 Use the Table of Standard Reduction Potentials (Table 4A or 4B) to explain why the magnesium can be used to protect an iron pipe against rusting. (2)
- 1.2.2 The iron pipe in contact with the magnesium bar forms an electrochemical cell. What serves as the salt bridge of this cell? (2)

- 1.2.3 Give a reason why the magnesium bar must be replaced after some time? (1)
- 1.2.4 Write down a half-reaction to support your answer to Question 1.2.3. (2)
- 1.2.5 Name TWO other methods that can be used to protect iron pipes against rust. (2)
- 1.2.6 State ONE advantage and ONE disadvantage of using plastic pipes instead of iron pipes. (2)
- [19]

**SECTION D: SOLUTIONS AND HINTS TO SECTION A**
**QUESTION 1**

- 1.1 Pb ✓ (1)
- 1.2  $Zn \rightarrow Zn^{2+} + 2e^-$  ✓✓ (2)
- 1.3  $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$  ✓  
 $= -0,13 \checkmark - (-0,76) \checkmark$   
 $E^\theta_{cell} = 0,63 \text{ V}$  ✓ (4)
- 1.4 Temperature ✓ and initial concentration of electrolytes. ✓ (2)
- 1.5  $Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$   
 (✓ for reactants, ✓ for products, ✓ for balancing) (3)
- 1.6  $Zn(s) / Zn^{2+}(aq) // Pb^{2+}(aq) / Pb(s)$   
 ✓                      ✓                      ✓ (3)
- 1.7.1 equal to ✓ (1)
- 1.7.2 area/size of electrodes has no effect on the emf of a cell. ✓✓ (2)
- 1.8.1 The cell has internal resistance. ✓✓ (2)
- 1.8.2 The emf decreases as the concentration of  $Pb^{2+}(aq)$  decreases. ✓✓ (2)

**OR**

 The cell is running flat as the electrolyte solution in the Pb cell decreases. **[22]**
**QUESTION 2**

- 2.1 Salt bridge ✓ (1)
- 2.2 Concentration of the electrolyte –  $1 \text{ mol} \cdot \text{dm}^{-3}$  ✓  
 Temperature –  $25^\circ \text{C} / 298 \text{ K}$  ✓ (2)
- 2.3  $Pb^{2+}$  ✓ / lead(II) ions / lead ions (1)
- 2.4  $E^\theta_{cell} = E^\theta_{cathode} - E^\theta_{anode}$  ✓  
 $1,53 \checkmark = (-0,13) \checkmark - E^\theta_{anode}$   
 $E^\theta_{anode} = -1,66 \text{ (V)}$  ✓  
 ✓ unknown metal X is Al ✓ (5)
- 2.5  $2Al + 3Pb^{2+} \rightarrow 2Al^{3+} + 3Pb$   
 (reactants ✓ ; products ✓ ; bal ✓ ) (3)
- 2.6 Decreases ✓✓ (2)
- 2.7  $0 \text{ V}$  ✓✓ (2)

**[16]**

**QUESTION 3**

- 3.1 P ✓ (1)
- 3.2.1 Ag / Silver ✓ (1)
- 3.2.2 Silver nitrate /  $\text{AgNO}_3$  ✓ or silver ethanoate /acetate / $\text{CH}_3\text{COOAg}$ .  
(These are the only two soluble silver salts.) (1)
- 3.3.1 Silver /metal bar becomes eroded /pitted/ smaller / thinner /eaten away ✓ (1)
- 3.3.2 A (silver) layer forms on the medal. ✓ (1)
- 3.4  $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$  ✓✓ (2)
- 3.5 Remains the same. ✓ (1)
- 3.6 Replace the silver solution with a copper solution ✓/soluble copper salt.  
Replace the silver bar/electrode P/anode with a copper bar. ✓ (2)
- [10]**

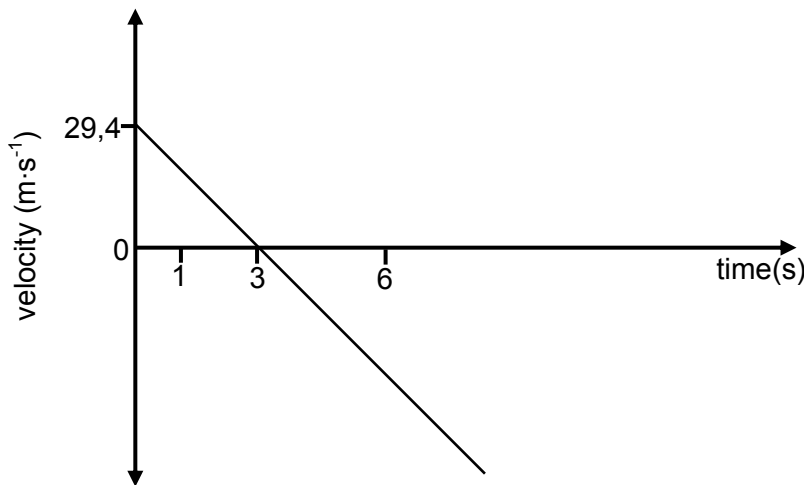
## SESSION 10

## TOPIC: CONSOLIDATION EXERCISES ON MECHANICS AND MATTER AND MATERIALS

## SECTION A: TYPICAL EXAM QUESTIONS

**QUESTION 1:** 20 minutes (Taken from the NSC Physical Sciences P1 Nov 2010)

A man fires a projectile **X** vertically upwards at a velocity of  $29,4 \text{ m}\cdot\text{s}^{-1}$  from the EDGE of a cliff of height 100 m. After some time the projectile lands on the ground below the cliff. The velocity-time graph below (NOT DRAWN TO SCALE) represents the motion of projectile **X**. (Ignore the effects of friction.)



- 1.1 Use the graph to determine the time that the projectile takes to reach its maximum height. (A calculation is not required.) (1)
- 1.2 Calculate the maximum height that projectile **X** reaches above the ground. (4)
- 1.3 Sketch the position-time graph for projectile **X** for the period  $t = 0 \text{ s}$  to  $t = 6 \text{ s}$ . USE THE EDGE OF THE CLIFF AS ZERO OF POSITION.

Indicate the following on the graph:

- The time when projectile **X** reaches its maximum height (4)
- The time when projectile **X** reaches the edge of the cliff

- 1.4 One second (1 s) after projectile **X** is fired, the man's friend fires a second projectile **Y** upwards at a velocity of  $49 \text{ m}\cdot\text{s}^{-1}$  FROM THE GROUND BELOW THE CLIFF.

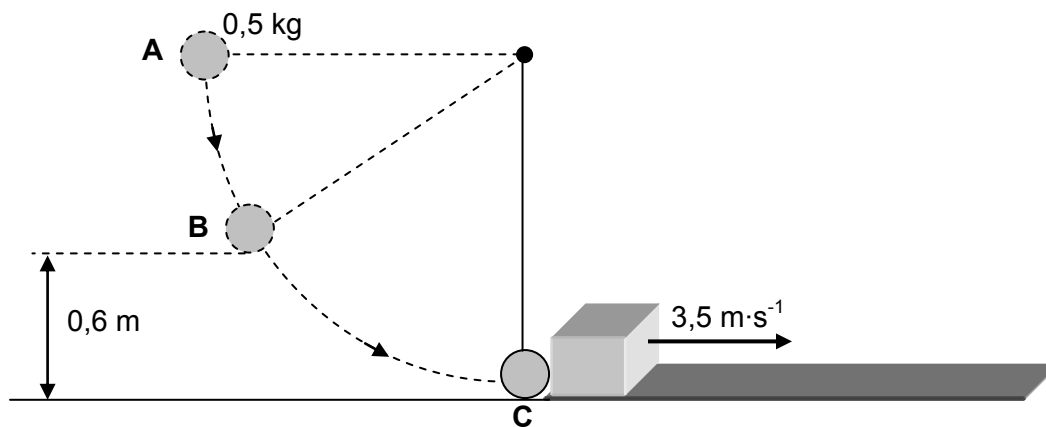
The first projectile, **X**, passes projectile **Y** 5,23 s after projectile **X** is fired. (Ignore the effects of friction.)

Calculate the following:

- 1.4.1 The velocity of projectile **X** at the instant it passes projectile **Y** (5)
- 1.4.2 The velocity of projectile **X** RELATIVE to projectile **Y** at the instant it passes projectile **Y** (5)  
[19]

**QUESTION 2: 15 minutes** (Taken from the NSC Physical Sciences P1 Nov 2010)

A steel ball of mass  $0,5 \text{ kg}$  is suspended from a string of negligible mass. It is released from rest at point **A**, as shown in the sketch below. As it passes through point **B**, which is  $0,6 \text{ m}$  above the ground, the magnitude of its velocity is  $3 \text{ m}\cdot\text{s}^{-1}$ . (Ignore the effects of friction.)



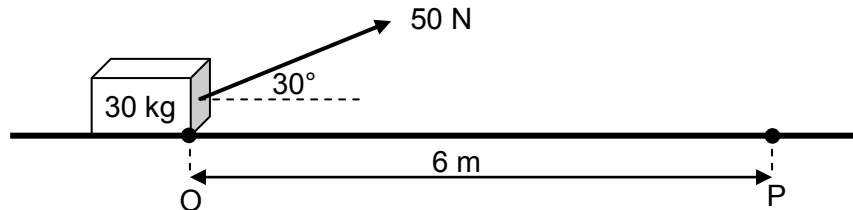
- 2.1 Write down the principle of the conservation of mechanical energy in words. (2)
- 2.2 Calculate the mechanical energy of the steel ball at point **B**. (4)

As the steel ball swings through its lowest position at point **C**, it collides with a stationary crate of mass  $0,1 \text{ kg}$ . Immediately after the collision, the crate moves at a velocity of  $3,5 \text{ m}\cdot\text{s}^{-1}$  to the right.

- 2.3 Calculate the velocity of the steel ball immediately after the collision. (7)  
[13]

**QUESTION 3:**      **20 minutes**      *(Taken from the NSC Physical Sciences P1 Nov 2010)*

A worker pulls a crate of mass 30 kg from rest along a horizontal floor by applying a constant force of magnitude 50 N at an angle of  $30^\circ$  to the horizontal. A frictional force of magnitude 20 N acts on the crate whilst moving along the floor.



- 3.1 Draw a labelled free-body diagram to show ALL the forces acting on the crate during its motion (4)
- 3.2 Give a reason why each of the vertical forces acting on the crate do NO WORK on the crate. (2)
- 3.3 Calculate the net work done on the crate as it reaches point P, 6 m from the starting point O. (4)
- 3.4 Use the work-energy theorem to calculate the speed of the crate at the instant it reaches point P (3)
- 3.5 The worker now applies a force of the same magnitude, but at a SMALLER ANGLE to the horizontal, on the crate.  
How does the work done by the worker now compare to the work done by the worker in QUESTION 3.3? Write down only GREATER THAN, SMALLER THAN or EQUAL TO.  
Give a reason for the answer. (No calculations are required.) (2)

[15]



**SECTION B: ADDITIONAL CONTENT NOTES**

No additional notes

**SECTION C: HOMEWORK****QUESTION 1: 12 minutes**

The photoelectric threshold frequency of copper is  $9,4 \times 10^{14}$  Hz.

- 1.1 What is the work function of copper? (3)
  - 1.2 With what maximum kinetic energy will electrons be ejected when light of frequency  $2,2 \times 10^{15}$  Hz is shone onto the copper. (5)
  - 1.3 What would the velocity of the electrons as they are ejected from the metal be? (4)
- [12]

**QUESTION 2: 11 minutes**

2. The threshold frequency of a certain metal is  $4,47 \times 10^{15}$  Hz.

- 2.1 Calculate the work function of the metal. (3)
  - 2.2 If light of wavelength 234 nm shines on the metal, find the maximum kinetic energy of the photoelectrons. (8)
- [11]

**QUESTION 3: 7 minutes**

The hydrogen alpha line in the solar spectrum has a wavelength of 656,285 nm. Remember that all stars are simply similar in nature to our sun and they should contain the same elements. The hydrogen alpha spectral line, that is detected on earth, in the light from a nearby star has a wavelength of 656,315 nm.

What can we conclude about the motion of this star? Briefly explain your answer. [5]

## SECTION D: SOLUTIONS AND HINTS TO SECTION A

**QUESTION 1**

1.1 3 seconds ✓ (1)

1.2 Either:

Area between graph and time axis

$$\Delta y = (\text{area of triangle}) / \frac{1}{2} bh \checkmark$$

$$= \frac{1}{2} (3)(29,4) \checkmark$$

$$= 44,1 \text{ m}$$

Maximum height above ground:

$$100 + 44,1 = 144,1 \text{ m} \checkmark$$

**OR**

From edge of cliff to max height.

**(Upward positive)**

$$v_f^2 = v_i^2 + 2a\Delta y \checkmark$$

$$\therefore 0^2 = 29,4^2 + 2(-9,8)\Delta y \checkmark$$

$$\therefore \Delta y = 44,1 \text{ m (43,22m)}$$

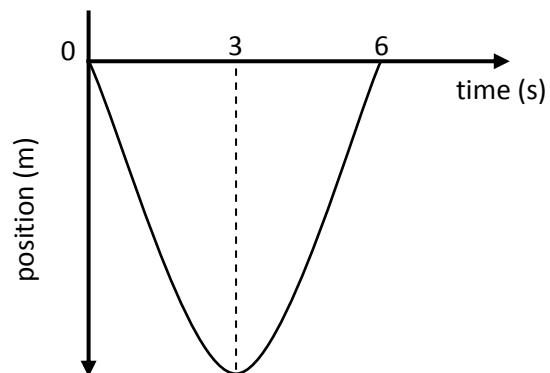
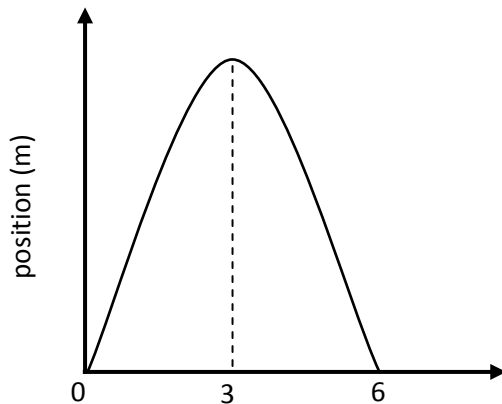
Maximum height above ground:

$$100 + 44,1 = 144,1 \text{ m} \checkmark$$

(4)

1.3

Checklist: Criteria for graph	Marks
Correct shape	✓
t = 3 s at maximum height	✓
t = 6 s at y = 0 m	✓
Graph starts at y = 0 m □ t = 0 s	✓



(4)

1.4.1

**OPTION 1:****Upward positive:**

$$\begin{aligned}
 v_f &= v_i + a\Delta t \quad \checkmark \\
 &= 29,4 \checkmark + (-9,8)(5,23) \checkmark \\
 &= -21,85 \text{ m}\cdot\text{s}^{-1} \checkmark \text{downwards} \checkmark
 \end{aligned}$$

**Downward positive:**

$$\begin{aligned}
 v_f &= v_i + a\Delta t \quad \checkmark \\
 &= -29,4 \checkmark + (9,8)(5,23) \checkmark \\
 &= 21,85 \text{ m}\cdot\text{s}^{-1} \checkmark \text{downwards} \checkmark
 \end{aligned}$$

OR

**OPTION 2**

$$\begin{aligned}
 \Delta y &= v_i \Delta t + \frac{1}{2} a \Delta t^2 \\
 &= 29,4 (5,23) + \frac{1}{2} (-9,8)(5,23)^2 \\
 &= 19,73 \text{ m} \quad (16,9975 \text{ m}) \\
 v_f^2 &= v_i^2 + 2a\Delta y \\
 &= 29,4^2 \checkmark + 2(-9,8)(19,73) \checkmark \\
 \therefore v_f &= 21,85 \text{ m}\cdot\text{s}^{-1} \checkmark \text{downwards} \checkmark
 \end{aligned}$$

(5)

## 1.4.2 Downward positive

$\Delta t = (5,23 - 1) \checkmark = 4,23 \text{ s}$ $v_f = v_i + a\Delta t \checkmark$ $= -49 + (9,8)(4,23) \checkmark$ $= -7,55 \text{ m}\cdot\text{s}^{-1}$ $v_f = 7,55 \text{ m}\cdot\text{s}^{-1} \text{ upwards}$	$v_{XY} = v_{XG} + v_{GY}$ $= 21,85 + (7,55)$ $v_{XY} = 29,40 \text{ m}\cdot\text{s}^{-1} \checkmark \text{ downwards} \checkmark$
	$v_{XY} = v_X - v_Y \text{ (vector difference)}$ $= 21,85 - (-7,55)$ $= 29,40 \text{ m}\cdot\text{s}^{-1} \checkmark \text{ downwards} \checkmark$
	$v_{XG} = v_{XY} + v_{YG}$ $21,85 = v_{XY} + (-7,55)$ $= 29,40 \text{ m}\cdot\text{s}^{-1} \checkmark \text{ downwards} \checkmark$

(5)  
[19]

## QUESTION 2

2.1 The sum of the kinetic and (gravitational) potential energy is conserved / constant / remains the same / does not change ✓ in an isolated / closed / system / no external work done / only conservative forces act on the system. ✓

OR

The (total) mechanical energy is conserved/ constant ✓ in an isolated system. ✓

(2)

2.2  $E_{\text{mech}} = U + K \text{ or } E_p + E_k$

$$= mgh + \frac{1}{2} mv^2 \checkmark$$

$$= (0,5)(9,8)(0,6) \checkmark + \frac{1}{2} (0,5)(3)^2 \checkmark$$

$$= 5,19 \text{ J} \checkmark$$

(4)

2.3

$$(U + K)_B = (U + K)_C \checkmark$$

$$mgh_B + \frac{1}{2} m v_B^2 = mgh_C + \frac{1}{2} m v_C^2$$

$$5,19 \checkmark = 0 + \frac{1}{2} (0,5)v^2 \checkmark$$

$$\therefore v = 4,56 \text{ m}\cdot\text{s}^{-1} \text{ (4,58 m}\cdot\text{s}^{-1})$$

$$\Sigma p_{\text{before}} = \Sigma p_{\text{after}}$$

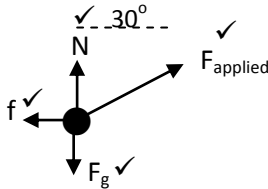
$$m_b v_{ib} + m_c v_{ic} = m_b v_{fb} + m_c v_{fc} \checkmark$$

$$(0,5)(4,56) + 0 \checkmark = (0,5)v_{fb} + (0,1)(3,5) \checkmark$$

$$\therefore v_{fb} = 3,86 \text{ m}\cdot\text{s}^{-1} \checkmark \text{ (to the right)}$$

(7)  
[13]**QUESTION 3**

3.1



N = normal force

 $f_f$  = force of friction $F_{\text{applied}}$  = applied force $F_g$  = force of gravity

(4)

3.2  $W = F\Delta x \cos 90^\circ \checkmark = 0 \checkmark$

OR

They (normal force and the gravitational force) are perpendicular /at  $90^\circ$  to the (direction of the) displacement / motion /  $\Delta x \checkmark \checkmark$  of the crate.

OR

The angle between the force and displacement / motion /  $\Delta x$  is  $90^\circ \checkmark \checkmark$ 

OR

The crate moves horizontally and the forces act vertically.  $\checkmark \checkmark$ 

(2)

3.3

$$\begin{aligned}
 W_{\text{net}} &= W_{\text{appl}} + W_f \quad \checkmark \\
 &= F_{\text{app}} \Delta x \cos \theta + f \Delta x \cos \theta \\
 &= (50)(6)(\cos 30^\circ) \checkmark + (20)(6)(\cos 180^\circ) \checkmark \\
 &= 259,81 + (-120) \\
 W_{\text{net}} &= 139,81 \text{ J} \checkmark
 \end{aligned}$$

(4)

3.4

$$W_{\text{net}} = \Delta E_k \quad \checkmark$$

$$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$139,81 = \frac{1}{2} (30) v_f^2 - 0 \quad \checkmark$$

$$v_f = 3,05 \text{ m} \cdot \text{s}^{-1} \quad \checkmark$$

(3)

3.5

Greater than  $\checkmark$  (Accept any equivalent word e.g. larger, etc.)

The horizontal component (of the force) / force in direction of motion will now be greater /  $F_{\text{net}}$  will now be greater.  $\checkmark$

(2)

**[15]**

## SESSION 11

## TOPIC: CONSOLIDATION EXERCISES ON SOUND, DOPPLER EFFECT AND LIGHT

## SECTION A: TYPICAL EXAM QUESTIONS

**QUESTION 1:** 10 minutes (Taken from DoE Additional Exemplar P1 2008)

The sketch below shows a stationary ambulance. The siren of the ambulance emits sound waves of frequency 700 Hz.

The driver of a car approaching the ambulance and passing it at constant speed, observes the frequency of the emitted sound waves to change by 80 Hz.



Stationary ambulance



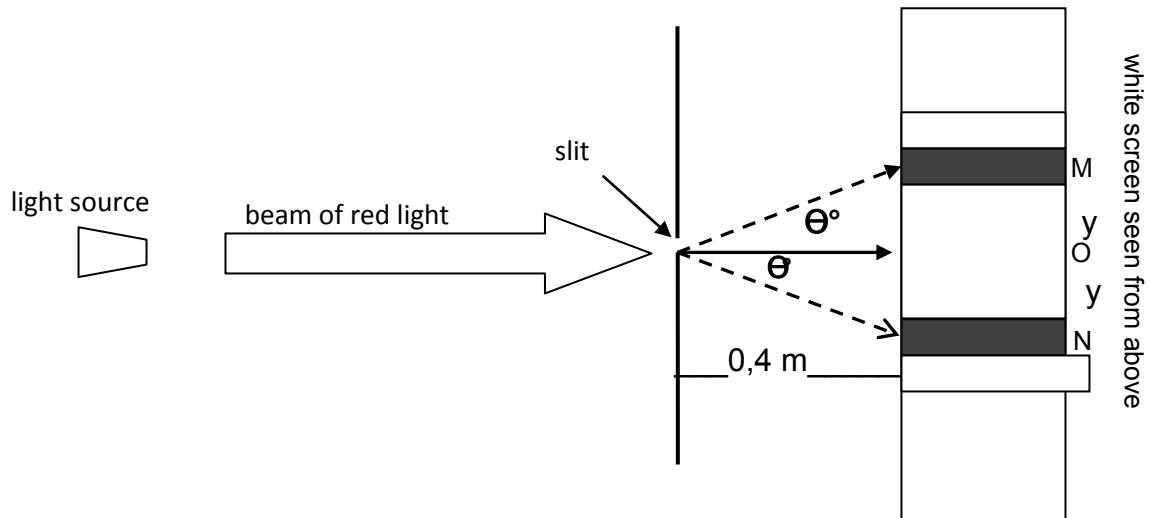
Car passing at constant speed

1.1 Name and state the wave phenomenon illustrated above. (3)

1.2 Take the speed of sound in air as  $340 \text{ m}\cdot\text{s}^{-1}$  and calculate the speed at which the car passes the ambulance. (5)  
[8]

**QUESTION 2:** 20 minutes (Taken from DoE Additional Exemplar P1 2008)

During a demonstration of a wave phenomenon, monochromatic red light passes through a slit of width  $1,8 \times 10^{-4} \text{ m}$  and shines on a flat screen a distance of 0,4 m away from the slit. The wavelength of the light is 675 nm.



- 2.1 Name the phenomenon demonstrated above. (1)
- 2.2 Briefly explain how the dark bands in the observed pattern are formed. (2)
- 2.3 Calculate the width  $2y$  of the central bright band. (6)
- 2.4 How will your answer to QUESTION 2.3 change if the width of the slit is changed to  $1,8 \times 10^{-6}$  m? Write only INCREASES, DECREASES or REMAINS THE SAME. Give a reason for your choice. (3)
- [12]

**QUESTION 3:** 10 minutes (Taken from the DoE NSC Nov 2010 Paper 1)

The siren of a burglar alarm system has a frequency of 960 Hz. During a patrol, a security officer, travelling in his car, hears the siren of the alarm of a house and approaches the house at constant velocity. A detector in his car registers the frequency of the sound as 1 000 Hz.

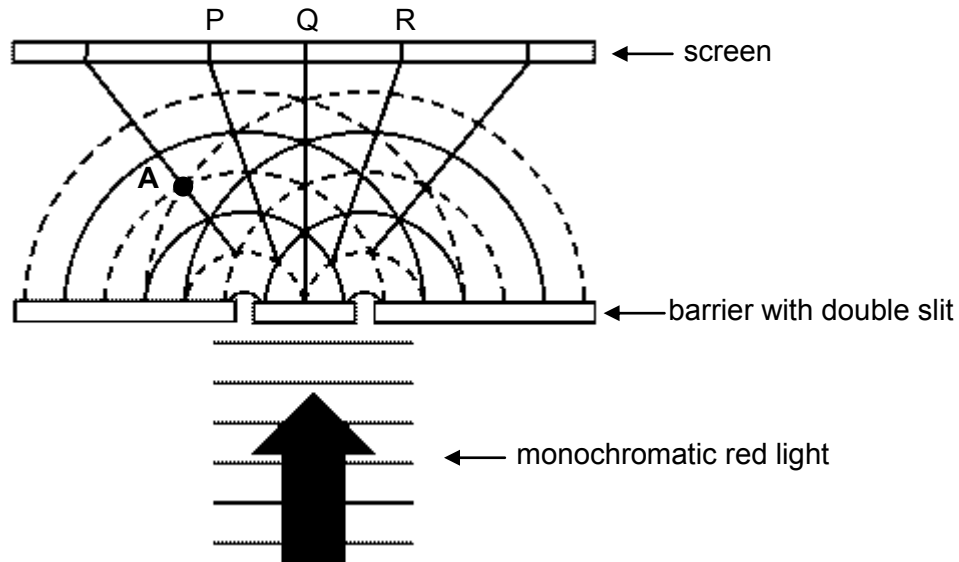
- 3.1 Name the phenomenon that explains the change in the observed frequency. (1)
- 3.2 Calculate the speed at which the patrol car approaches the house. Use the speed of sound in air as  $340 \text{ m}\cdot\text{s}^{-1}$ . (4)
- 3.3 If the patrol car had approached the house at a higher speed, how would the detected frequency have compared to the first observed frequency of 1 000 Hz? Write down only HIGHER THAN, LOWER THAN or EQUAL TO. (1)
- [6]



**QUESTION 4:** 10 minutes (Taken from the DoE NSC Nov 2010 Paper 1)

Monochromatic red light passes through a double slit, as shown in the diagram below. Circular wave fronts, advancing towards the screen, are shown between the slits and the screen as dotted lines and solid lines. The solid lines represent crests and the dotted lines represent troughs.

Interference of the circular wave fronts results in an interference pattern observed on the screen. **P**, **Q** and **R** represent the centres of different bands in the interference pattern.



- 4.1 Define the term *interference*. (2)
- 4.2 What type of interference takes place at point **A**? Give a reason for the answer. (2)
- 4.3 Is band **P** a dark band or a red band? Refer to the type of interference involved to explain how you arrived at the answer. (3)
- [7]

<b>SECTION B: ADDITIONAL CONTENT NOTES</b>
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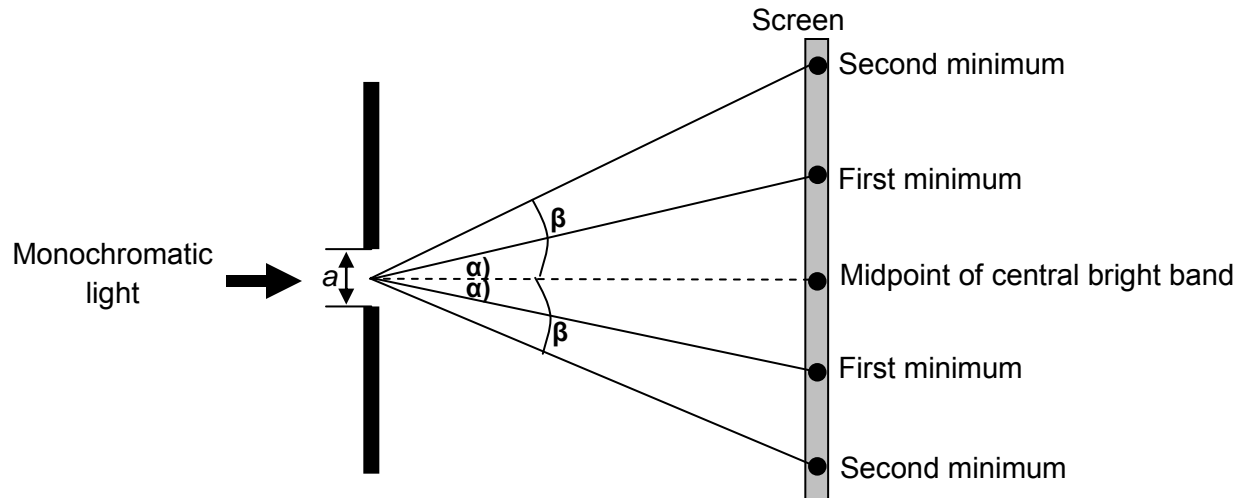
No additional notes

<b>SECTION C: HOMEWORK</b>
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**QUESTION 1:**                      **15 minutes**    (*Taken from the DoE NSC Nov 2010 Paper 1*)

The relationship between the degree of diffraction of light and slit width is investigated.

Monochromatic light of wavelength 410 nm is passed through a single slit at a *fixed distance* from a screen. The angles at which the first minimum ( $\alpha$ ) and the second minimum ( $\beta$ ) occur are measured.



The experiment is repeated using the same light source but a slit of different width.

The results obtained from the two experiments are represented in the table below

	ANGLE OF 1 <sup>ST</sup> MINIMUM ( $\alpha$ )	ANGLE OF 2 <sup>ND</sup> MINIMUM ( $\beta$ )
<b>Slit 1</b>	10°	20°
<b>Slit 2</b>	5°	10°

- 1.1 Define the term *diffraction*. (2)
- 1.2 For this investigation, name the following: (1)
- 1.2.1 Dependent variable (1)
- 1.2.2 Independent variable (1)
- 1.3 Which ONE of **Slit 1** or **Slit 2** is the narrower slit? Explain the answer. (2)
- 1.4 Use the data in the table to calculate the width of **Slit 2**. (4)

[10]

**QUESTION 2: 5 minutes**

Huygens' Principle is used to explain the wave phenomena, interference and diffraction.

2.1 State Huygens' Principle. (2)

2.2 Use Huygens' Principle to explain the diffraction of water waves in a ripple tank as they pass through a narrow opening in a barrier. (3)  
[5]

**SECTION D: SOLUTIONS AND HINTS TO SECTION A****QUESTION 1**

1.1 Doppler effect ✓

A change in observed frequency (pitch) due to relative motion between observer and sound source. ✓✓

**OR**

A change in observed frequency (pitch) because the sound source and observer have different velocities with respect to the medium. ✓✓ (3)

1.2

$$f_L = \frac{v \pm v_L}{v \pm v_S} \cdot f_S \quad \checkmark$$

When the car approaches  $f_L = \frac{340+v_L}{340} \times 700 \checkmark$

When the car moves away  $f_L = \frac{340-v_L}{340} \times 700 \checkmark$

$$\frac{340+v_L}{340} \times 700 - \frac{340-v_L}{340} \times 700 = 80 \quad \checkmark$$

$$v_L = 19,43 \text{ m} \cdot \text{s}^{-1} \quad \checkmark \quad (5)$$

**[8]**



**Learner Note:** Simultaneous equations may be difficult to do. Take time and care when going through the steps and do not take short cuts.

**QUESTION 2**

2.1 Diffraction (1)

2.2 Wavelets originating from different points in the slit reach the screen out of phase and interfere destructively on the screen. (2)

2.3

$$\sin \theta = \frac{m\lambda}{a} \checkmark$$

$$\sin \theta = \frac{(1)675 \times 10^{-9}}{1,8 \times 10^{-4}} \checkmark$$

$$\theta = 0,21^\circ \checkmark$$

$$\tan 0,21^\circ = y/0,4 \checkmark$$

$$y = 1,47 \times 10^{-3} \text{ m (1,47 mm)} \checkmark$$

Width of central bright band

$$2y = 2(1,47 \times 10^{-3}) = 2,93 \times 10^{-3} \text{ m (2,93 mm)} \checkmark \quad (6)$$

2.4 Increases ✓

Diffraction is inversely proportional to the width of the slit. ✓✓

**OR**

Amount of diffraction is determined by the ratio  $\lambda/a$ . If  $a$  decreases,  $\lambda/a$  will increase. ✓✓ (3)

**[12]**



**Learner Note:** Ask your teacher for help if you cannot use the scientific notation on your calculator and do not forget to convert the units of milli, micro, nano etc into the equations.

**QUESTION 3**

3.1 Doppler effect ✓ (1)

$$3.2 \quad f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

$$\therefore 1\,000 \checkmark = \frac{340 + v_L}{340} (960) \checkmark$$

$$\therefore v_L = 14,17 \text{ m} \cdot \text{s}^{-1} \checkmark \quad (4)$$

3.3 Higher than ✓ (1)

**[6]**

**QUESTION 4**

4.1 When two waves pass through the same region of space at the same time ✓, resulting in the superposition of waves / net amplitude / net energy. ✓

**OR**

Two waves meet /cross / interact / overlap / collide ✓  
resulting in the superposition / reinforcement /cancellation / net amplitude / net energy  
of the waves. ✓ (2)

4.2 Constructive (interference) ✓

The waves crossing each other are in phase. ✓ / Two troughs meet. /

The path difference is an integer number of  $\lambda$ . (2)

4.3 Dark band ✓

It lies on the line combining all the points where crests and troughs overlap ✓ resulting in destructive interference. ✓

**OR**

It lies on the (nodal) line ✓ where destructive interference occurs. ✓ (3)

**[7]**

## SESSION 12

## TOPIC: CONSOLIDATION EXERCISES ON ORGANIC MOLECULES AND THEIR REACTIONS

## SECTION A: TYPICAL EXAM QUESTIONS

**QUESTION 1:** 17 minutes (Taken from the DoE NSC Nov 2010 Paper 2)

The chemical properties of organic compounds are determined by their functional groups. The letters **A** to **F** in the table below represent six organic compounds

<p><b>A</b></p> $  \begin{array}{cccc}  \text{H} & \text{H} & \text{H} & \text{H} \\    &   &   &   \\  \text{C} & = & \text{C} & - & \text{C} & - & \text{C} & - & \text{H} \\    & &   & &   & &   \\  \text{H} & & \text{H} & & \text{H} & & \text{H}  \end{array}  $	<p><b>B</b></p> $  \begin{array}{c}  \text{H} \\    \\  \text{H} - \text{C} - \text{H} \\    \\  \text{H} \quad \quad \quad \text{H} \\    \quad \quad \quad   \\  \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\    \quad   \quad   \\  \text{Br} \quad \text{H} \quad \text{H}  \end{array}  $	<p><b>C</b></p> $  \begin{array}{ccccccc}  & & & & \text{H} & & \\  & & & &   & & \\  & & & & \text{H} - \text{C} - \text{H} & & \\  & & & &   & & \\  \text{H} & \text{H} & \text{H} & \text{H} & & \text{H} & \\    &   &   &   & &   & \\  \text{H} - \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{C} - & \text{H} \\    &   &   &   &   &   & \\  \text{H} & \text{H} & & \text{H} & \text{H} & \text{H} & \\  & & & &   & & \\  & & & & \text{H} - \text{C} - \text{H} & & \\  & & & &   & & \\  & & & & \text{H} & &   \end{array}  $
<p><b>D</b></p> <p>Methanal</p>	<p><b>E</b></p> $  \begin{array}{c}  \text{H} \quad \quad \text{O} \\    \quad \quad    \\  \text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\    \\  \text{H}  \end{array}  $	<p><b>F</b></p> <p>Methyl methanoate</p>

1.1 Write down the LETTER that represents the following:

1.1.1 An alkene

(1)

1.1.2 An aldehyde

(1)

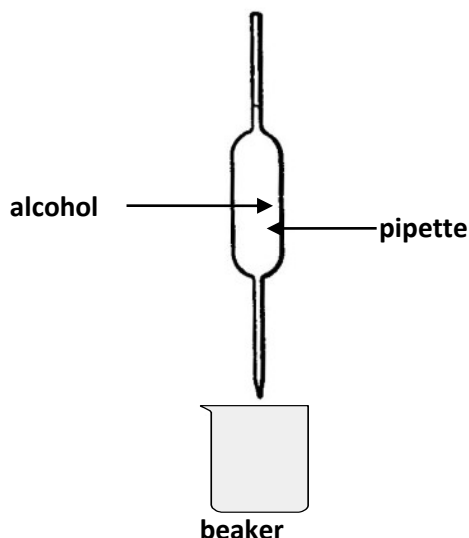
- 1.2 Write down the IUPAC name of the following:
- 1.2.1 Compound **B** (2)
- 1.2.2 Compound **C** (2)
- 1.3 Write down the structural formula of compound **D**. (2)
- 1.4 Write down the IUPAC name of the carboxylic acid shown in the table. (2)
- 1.5 Write down the structural formula of compound **F**. (2)
- [12]

**QUESTION 2:** 18 minutes (Taken from the DoE NSC Nov 2010 Paper 2)

Five alcohols represented by the letters **A – E** are listed in the table below.

<b>A</b>	Methanol	<b>B</b>	Ethanol
<b>C</b>	Propan-1-ol	<b>D</b>	Butan-2-ol
<b>E</b>	2-methylpropan-2-ol		

- 2.1 Which ONE of the above alcohols is a SECONDARY alcohol? Write down only the LETTER that represents the alcohol. (1)
- 2.2 The letter **E** represents 2-methylpropan-2-ol. For this alcohol, write down the following:
- 2.2.1 Its structural formula (2)
- 2.2.2 The LETTER in the table that represents one of its structural isomers (1)
- 2.3 Viscosity is a measure of a fluid's resistance to flow. Learners conduct an investigation to compare the viscosities of the first three alcohols (**A – C**) in the table above. They use the apparatus shown below.



The learners use the stopwatch to measure the time it takes a FIXED VOLUME of each of the alcohols to flow from the pipette. They record this flow time, which is an indication of the viscosity of each alcohol, as given in the table below.

	Alcohol	Flow time (s)
<b>A</b>	Methanol	4,0
<b>B</b>	Ethanol	7,9
<b>C</b>	Propan-1-ol	14,3

- 2.3.1 Formulate an investigative question for this investigation. (2)
- 2.3.2 Which ONE of the alcohols (**A**, **B**, or **C**) has the highest viscosity? (2)  
Use the data in the table to give a reason for the answer.
- 2.3.3 Refer to the intermolecular forces of the three alcohols (**A**, **B** and **C**) to explain the trend in viscosities as shown in the table. (2)
- 2.3.4 Lubricants reduce friction. Which one of alcohols, **A**, **B** or **C**, will be the best lubricant? (1)
- 2.4 Which ONE of 2-methylpropan-2-ol and butan-2-ol has the higher viscosity? (1)
- 2.5 Refer to intermolecular forces to explain the answer to QUESTION 2.4. (2)  
[14]

**QUESTION 3:**                    **20 minutes**                    (*Taken from the DoE NSC Nov 2010 Paper 2*)

Prop-1-ene is a flammable alkene.

- 3.1 Why is prop-1-ene considered to be a dangerous compound? (1)

Through addition reactions, prop-1-ene can be converted to other compounds, such as alkanes and alcohols.

- 3.2 Which part of the structure of an alkene allows it to undergo addition reactions? (1)
- 3.3 In one type of addition reaction, prop-1-ene can be converted to an alcohol.
- 3.3.1 Use structural formulae to write a balanced equation for the formation of the alcohol during this addition reaction. (4)
- 3.3.2 Name the type of addition reaction that takes place. (1)
- 3.3.3 Write down the name or formula of the catalyst used in this reaction. (1)



- 3.4 Use molecular formulae to write down a balanced chemical equation for the complete combustion of propane. (3)  
 Prop-1-ene can be produced from an alcohol by an elimination reaction.
- 3.5 Use structural formulae to write a balanced chemical equation for the formation of prop-1-ene from a PRIMARY alcohol. (4)
- 3.6 Name the type of elimination reaction that takes place. (1)  
 [16]

### SECTION B: ADDITIONAL CONTENT NOTES

No additional notes

### SECTION C: HOMEWORK

#### QUESTION 1

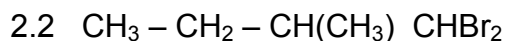
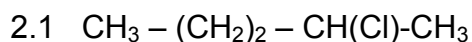
Define the following terms::

- 1.1 structural isomer
- 1.2 general formula
- 1.3 homologous series
- 1.4 functional group

[8]

#### QUESTION 2

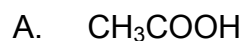
Draw structural formulae for each of the following:



[4]

#### QUESTION 3

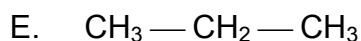
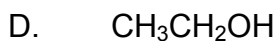
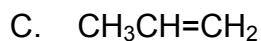
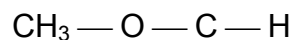
Study the following formulae:



B.

O

||



From the above compounds listed write down only the letters representing:

3.1 TWO substances that react to form an ester.

3.2 TWO substances that can be structural isomers of each other.

3.3 ONE substances that is an unsaturated hydrocarbon.

3.4 ONE substance that is a saturated hydrocarbon. [8]

<b>SECTION D: SOLUTIONS AND HINTS TO SECTION A</b>
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### QUESTION 1

1.1

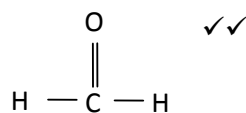
1.1.1 A ✓ (1)

1.1.2 D ✓ (1)

1.2.1 1-bromo-2-methylpropane ✓✓ (2)

1.2.2 2,4-dimethylhexane ✓✓ (2)

1.3

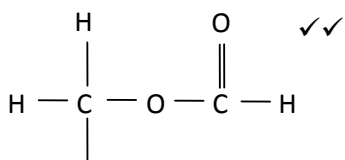


(2)

1.4 Ethanoic acid ✓✓

(2)

1.5



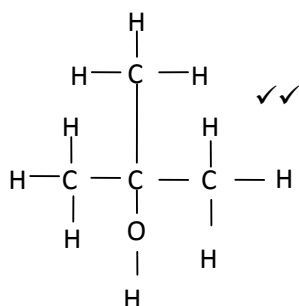
(2)

**[12]**

## QUESTION 2

2.1 D ✓ (1)

2.2.1



(2)

2.2.2 D ✓ (1)

2.3 2.3.1

Criteria for investigative question	Mark
The <u>dependent</u> and <u>independent</u> variables are stated.	✓
Asks a question about the relationship between <u>dependent</u> and <u>independent</u> variables.	✓

**Example:**

What is the relationship between viscosity / flow time and chain length / number of C atoms / molecular mass / molecular size / molar mass / surface area / number of electrons / alcohols?

(or vice versa.)

How does /will the viscosity change when the chain length increases?

How are the viscosities of the alcohols related to their molar masses?

How does the viscosities of the first three alcohols compare?

(2)

2.3.2 C ✓

Longest flow time /flows the slowest / most resistance to flow ✓

(2)

2.3.3 Increase in chain length / molecular mass / molar mass / molecular size / surface area from A to C. ✓

Increase in (strength of) intermolecular / Van der Waals / dispersion / London / forces ✓

(2)

2.3.4 C ✓

(1)

2.4 D ✓ (1)

2.5 The more branched /more compact /more spherical alcohol / E has a smaller surface area (over which the intermolecular forces act). ✓  
Decrease in (strength of) intermolecular forces / Van der Waals / dispersion / London /forces ✓ reduces resistance to flow (and thus lower viscosity). (2)

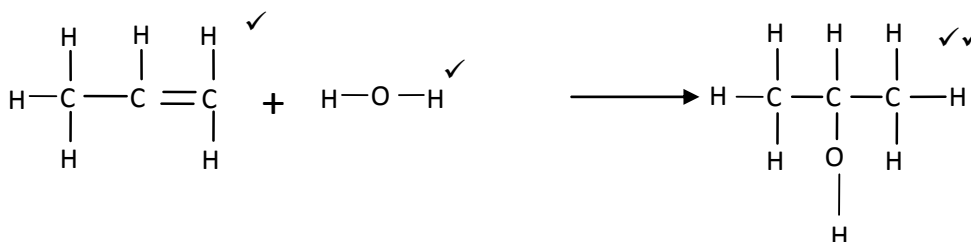
**[14]**

### QUESTION 3

3.1 Prop-1-ene is (highly) flammable. ✓ (1)

3.2 Alkenes contain a double (carbon – carbon) / (C=C) / bond. ✓. (1)

3.3 3.3.1



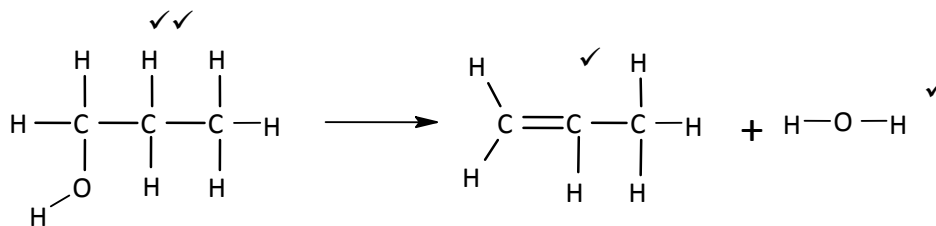
(4)

3.3.2 Hydration ✓ (1)

3.3.3 Sulphuric acid ✓ (1)

3.4  $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$   
(reactants ✓ ; products ✓ ; bal ✓) (3)

3.5



(4)

3.6 Dehydration ✓ (1)

**[16]**

## SESSION 13

## TOPIC: CONSOLIDATION EXERCISES ON RATES, CHEMICAL EQUILIBRIUM AND ELECTROCHEMISTRY

## SECTION A: TYPICAL EXAM QUESTIONS

## QUESTION 1: 20 minutes

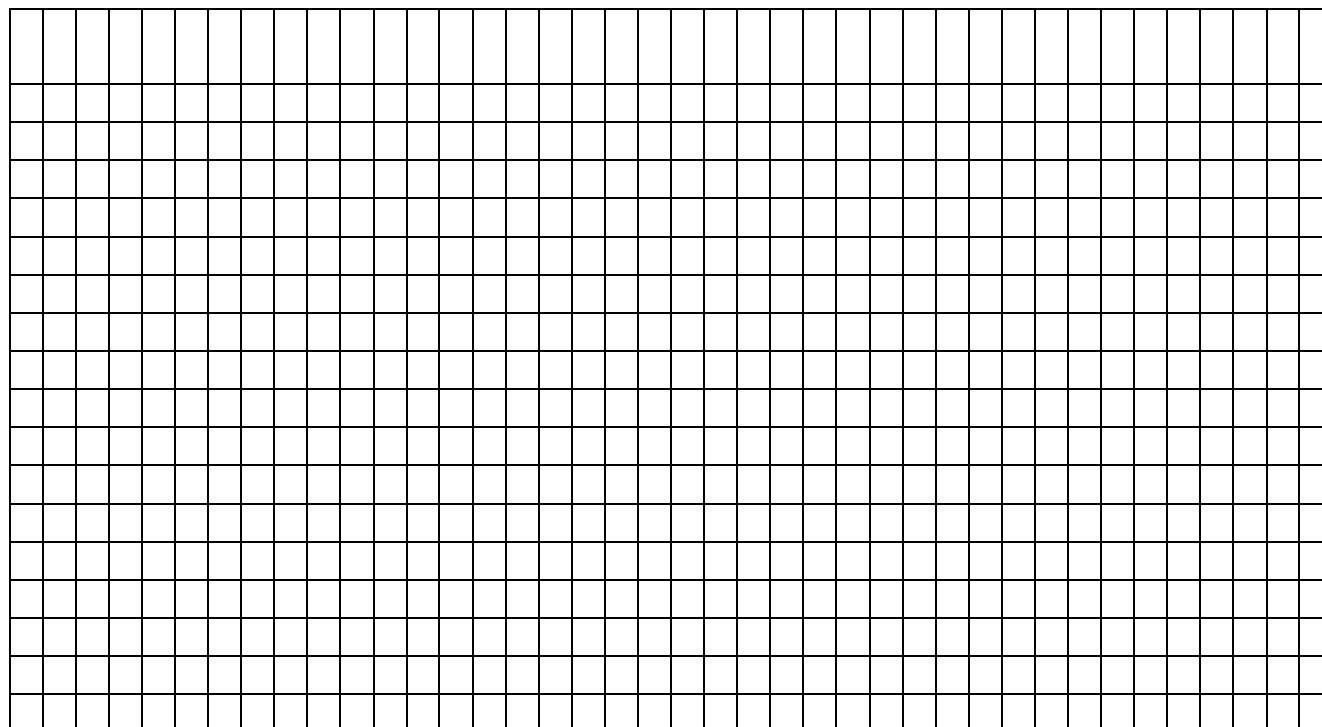
In order to investigate the rate at which a reaction proceeds, a learner places a beaker containing concentrated nitric acid on a sensitive balance. A few pieces of copper metal are dropped into the nitric acid. Mass readings of the beaker and its contents are recorded every 15 s, from the moment the copper metal is dropped into the acid until shortly after there is no more copper metal present.

The mass readings taken during the investigation are given in the table below. The time at which the copper is dropped into the acid is recorded as 0 seconds.

Time (s)	Mass of beaker and contents (g)	Decrease in mass (g)
0	114,6	0
15	113,0	0,6
30	111,6	2,2
45	110,4	4,2
60	109,4	5,2
75	108,7	5,9
90	108,4	6,2
105	108,3	6,3
120	108,3	6,3
135	108,3	6,3
150	108,3	6,3

- 1.1 Which of the two physical quantities, time or mass, is the independent variable in this investigation. Explain your answer. (3)

1.2. Using the readings given in the table, plot a graph on this page of *decrease mass* versus *time*.



(7)

1.3. From the gradient of the graph it can be seen that the rate of the reaction change with time. Explain why the following changes in rate occur.

1.3.1 Reaction rate increases between 0 and 30s. (2)

1.3.2 Reaction rate decreases between 45 and 105s. (2)

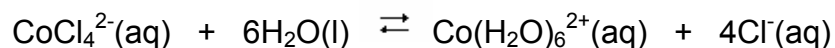
1.3.3 After 105 s the rate becomes zero. (2)

1.4 State two ways in which the rate of this reaction could be increased. (4)

[20]

**QUESTION 2: 20 minutes**

A small quantity of cobalt chloride powder is dissolved in ethanol resulting in a blue solution. When a few drops of water are carefully added to the blue solution the colour changes to pink. The following equilibrium has been established:



blue

pink

To investigate the factors which affect this equilibrium, the following experiments were performed:

Experiment 1: A small quantity of concentrated HCl is added to the solution.

2.1 Observation:..... (1)

Experiment 2: The test tube with the solution is cooled by immersing it in ice water.

2.2 Observation:..... (1)

Experiment 3: A few drops of silver nitrate are added to the solution.

2.3 Observation:..... (2)

- 2.4 Tabulate your observations: (3)
- 2.5 Name the effect that is illustrated in experiment 1. (1)
- 2.6 Was the forward or reverse reaction favoured as a result of the addition of the concentrated HCl? (1)
- 2.7 Use your observation in experiment 2 to state whether the forward reaction is exothermic or endothermic. (1)
- 2.8 Make use of Le Chatelier's principle to justify your answer in 2.7. (4)
- 2.9 In experiment 3, a white precipitate is formed when the silver nitrate is added.
- 2.9.1 Give the name of the white solid. (1)
- 2.9.2 Give the balanced chemical equation to explain the formation of the white precipitate. (3)
- 2.9.3 Explain how the addition of the silver nitrate affected the equilibrium. (3)
- [21]

**QUESTION 3: 15 minutes**

Two half-cells,  $\text{Pb}^{2+}/\text{Pb}$  and  $\text{O}_2/\text{H}_2\text{O}$ , in an acid solution are used to set up an electrochemical cell. The cell operates under standard conditions.

- 3.1 Give the standard conditions that apply to this electrochemical cell. (4)
- 3.2 Which half-cell represents the anode? (2)
- 3.3 Give the equation for the oxidation half-reaction. (2)
- 3.4 Give the equation for the reduction half-reaction. (2)
- 3.5 Give the balanced equation for the net reaction. (2)
- 3.6 Calculate the emf of the cell. (4)

[16]

**SECTION B: ADDITIONAL CONTENT NOTES**

No additional content notes

**SECTION C: HOMEWORK****QUESTION 1: 15 minutes**

A silver-nickel voltaic cell is made under standard conditions.

- 1.1 Give the reduction half-reaction. (2)
  - 1.2 Write the half-reaction that occurs at the anode. (2)
  - 1.3 Which electrode increases in mass when the cell is used? (2)
  - 1.4 Give the cell notation for this cell. (3)
  - 1.5 What is the emf of this cell? (4)
- [13]

**QUESTION 2: 16 minutes**

2.1 Lowering the temperature of an equilibrium reaction will:

- A decrease the rate of the forward reaction only.
- B decrease the rate of the reverse reaction only.
- C decrease the rate of both the forward and reverse reactions.
- D have no effect on the rate of reaction.

2.2 Assuming equilibrium is reached in the reaction:

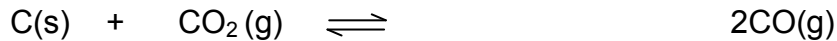


A greater yield of carbon dioxide can be obtained by ...

- A raising the temperature and pressure.
- B raising the temperature and lowering the pressure.
- C lowering the temperature and pressure.
- D lowering the temperature and raising the pressure.



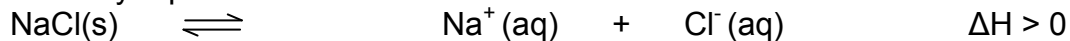
- 2.3 Carbon, carbon dioxide and carbon monoxide are in equilibrium in a container of which the volume can change. The balanced equation for the equilibrium reaction is as follows:



While the temperature is kept constant, the volume of the container is decreased and a new equilibrium is established. Which one of the following statements regarding the number of moles of CO and the concentration of CO at the new equilibrium condition is correct?

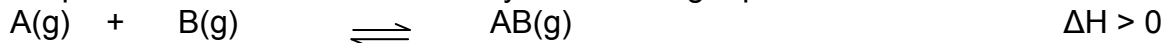
	Number of moles of CO	[CO]
A	the same	greater
B	Less	greater
C	Less	less
D	More	the same

- 2.4 A saturated solution of NaCl in water is prepared at 60°C. The equation for this solubility equilibrium is:



Which one of the following changes will cause more NaCl<sub>(s)</sub> to form?

- A add H<sub>2</sub>O.
  - B add a catalyst.
  - C increase temperature.
  - D decrease temperature.
- 2.5 Two substances, A and B, are in equilibrium with their product, AB, at a temperature of 10°C as indicated by the following equation:

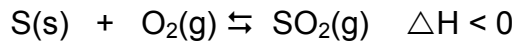


At 10°C the rate of the forward reaction is equal to  $x \text{ mol}\cdot\text{s}^{-1}$ .

The temperature is then increased. Which statement regarding the forward and reverse reaction rates is correct at the higher temperature?

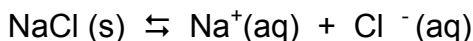
	Forward rate	Reverse rate
A	equal to $x$	equal to $x$
B	less than $x$	less than $x$
C	greater than $x$	greater than $x$
D	less than $x$	greater than $x$

- 2.6. When an amount of sulphur and oxygen are sealed in a container at 700K, an equilibrium is established according to the following equation:



If the pressure is increased, while the temperature of 700K is maintained, the:

- A value of  $K_c$  increase
  - B volume of the gases increase
  - C amount of  $\text{SO}_2$  decreases
  - D amount of  $\text{O}_2$  remains the same.
- 2.7. The following equilibrium exists in a saturated salt solution.

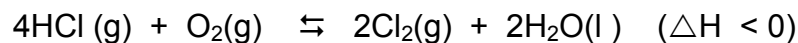


What can be done in order to obtain a precipitate of NaCl ?

- A Increase the pressure on the system
  - B Heat the solution
  - C Add concentrated Hydrochloric acid (HCl)
  - D Bubble chlorine ( $\text{Cl}_2$ ) through the solution.
- 2.8. In which of the following reactions will a *decrease* in pressure cause the yield of the product(s) to *increase*?

- A  $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$
- B  $2 \text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$
- C  $2 \text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
- D  $2 \text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$

- 2.9. Consider the following system which is in equilibrium:



The yield of chlorine gas can best be *increased* by the following combination of changes in temperature and pressure:

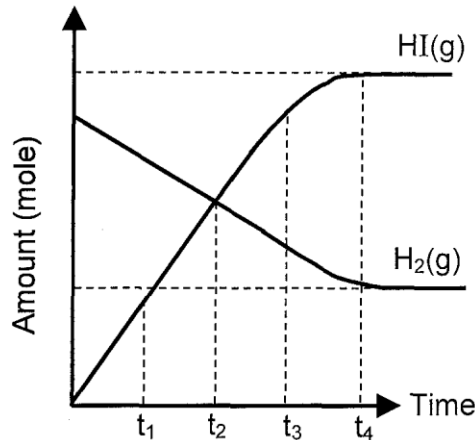
	Temperature	Pressure
A	Increase	Decrease
B	decrease	Decrease
C	decrease	Increase
D	increase	Increase

2.10. The following reversible reaction is used in the production of hydrogen iodide gas:

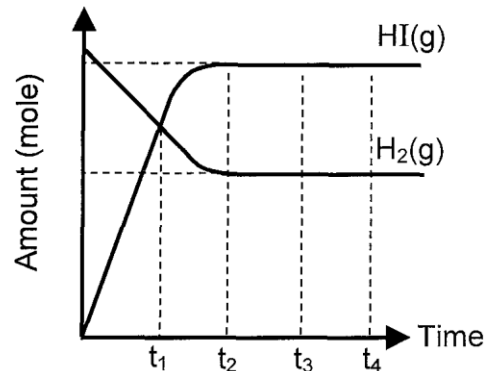


The graph X of amount of reagents against time was obtained when the reaction was carried out under certain conditions.

The graph Y was obtained for the same experiment using the same amount of  $\text{H}_2(\text{g})$ , but certain changes were made to the conditions affecting the system.



GRAPH X

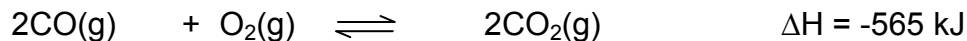


GRAPH Y

2.11 Which one of the following sets of changes could have been introduced to the system to obtain graph Y?

- A More  $\text{I}_2(\text{g})$  was added and the temperature was decreased.
- B The temperature and pressure was decreased.
- C A catalyst was added and the temperature was increased.
- D A catalyst was added and the temperature was decreased.

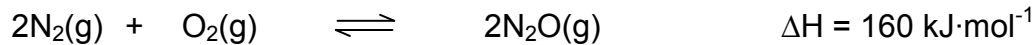
2.12. Assuming equilibrium is reached in the reaction:



A greater yield of carbon dioxide can be obtained by:

- A raising the temperature and pressure.
- B raising the temperature and lowering the pressure.
- C lowering the temperature and the pressure.
- D lowering the temperature and raising the pressure.

2.13. Consider the following equilibrium reaction:



Which ONE of the following changes gives the greatest increase in the equilibrium yield of  $\text{N}_2\text{O}$ ?

	TEMPERATURE	PRESSURE
A	Decrease	Increase
B	Decrease	Decrease
C	Increase	Increase
D	Increase	Decrease

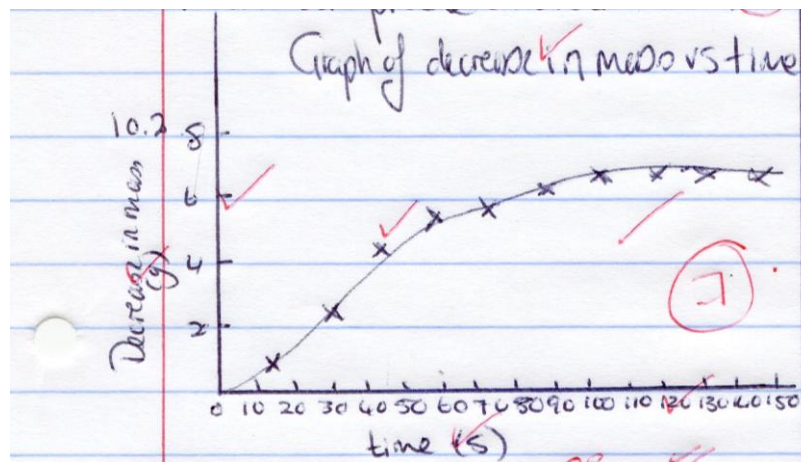
(13 x 2) [26]

### SECTION D: SOLUTIONS AND HINTS TO SECTION A

#### QUESTION 1

1.1 Time. ✓ It was decided to measure mass at predetermined times. ✓✓ (3)

1.2



(7)

1.3.1  $\text{Cu}$  and  $\text{HNO}_3$  reacting together initially and rate is quick ✓✓ (2)

1.3.2  $\text{HNO}_3$  concentration and  $\text{Cu}$  surface area decreasing ✓✓ (2)

1.3.3 reaction has reached completion. ✓✓ (2)

1.4. heated, ✓✓ copper surface area increased, ✓✓ concentration of nitric acid increased ✓✓ (Any two) (4)

[20]

**QUESTION 2**

2.1 Clear pink solution turns blue✓ (1)

2.2 Clear blue solution turns pink✓ (1)

2.3 Clear blue solution turns opaque pink solution (pink with white ppt) ✓✓ (2)

2.4.

Equilibrium disturbance	Observation
Addition of HCl	Pink to blue✓
Cooling of solution	Blue to pink✓
Addition of AgNO <sub>3</sub>	Blue to opaque pink✓

(3)

2.5. Common ion effect ✓ (1)

2.6. Reverse reaction ✓ (1)

2.7. Exothermic ✓ (1)

2.8. The decrease in temperature favours the exothermic reaction✓. The solution Went from blue to pink ✓→ forward reaction favoured. ✓ So forward reaction is exothermic✓. (4)

2.9.1. Silver chloride ✓ (1)

2.9.2.  $\text{Ag}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \rightarrow \text{AgCl} (\text{s})$ ✓ (3)

2.9.3. Silver nitrate reacts with Cl<sup>-</sup> ions thus removing them from the solution. ✓The concentration of chloride ions decreases so the equilibrium shifts so as to accommodate that change. The forward reaction is thus favoured✓. and the solution turns pink. ✓. (3)

**[21]**

**QUESTION 3**

3.1 Concentration of Pb<sup>2+</sup>(1M) ✓; H<sup>+</sup>(1M) ✓; pressure of O<sub>2</sub> 1 atm✓; Temperature 25°C✓ (4)

3.2 Pb✓✓ (2)

3.3  $2\text{Pb} (\text{s}) \rightarrow 2\text{Pb}^{2+} (\text{aq}) + 4\text{e}^-$ ✓✓ (2)

3.4  $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$ ✓✓ (2)

3.5  $2\text{Pb} + \text{O}_2 + 4\text{H}^+ \rightarrow 2\text{H}_2\text{O} + 2\text{Pb}^{2+}$ ✓✓ (2)

3.6  $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$  ✓  
 $= 1,23 \text{ V} - (-0,13) \text{ V}$  ✓  
 $E_{\text{cell}}^{\theta} = 1,36 \text{ V}$  ✓ (4)

**[16]**

**QUESTION 4**

4.1. D ✓✓

4.2. A ✓✓

4.3. B ✓✓

4.4. A ✓✓

4.5. C ✓✓

4.6. C ✓✓

4.7. A ✓✓

4.8. C ✓✓

(2 x 8) [16]

**SESSION 14****TOPIC 1: ELECTROSTATICS - GRADE 11 REVISION****SECTION A: TYPICAL EXAM QUESTIONS****QUESTION 1: 10 minutes***(Taken from the DoE Physical Sciences Feb-March Paper 1 2010)*

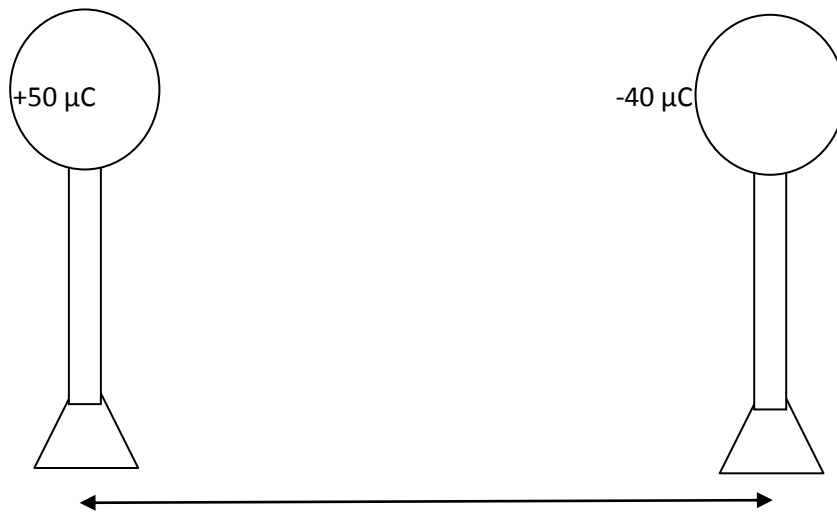
Capacitors are circuit devices used to store electrical energy. The capacitance of capacitors depends, amongst other factors, on the plate area. The larger the plate area, the more the energy that can be stored.

- 1.1 Apart from plate area, state TWO other factors that can influence the capacitance of a capacitor. (2)
- 1.2 A certain parallel plate capacitor consists of two plates, each having dimensions of 2cm by 10cm. The plates are 0,2mm apart and are held at a potential difference of 20V. The space between the plates is filled with air.
- 1.2.1 Sketch the electric field pattern between the two oppositely charged parallel plates of the capacitor. (3)
- 1.2.2 Calculate the capacitance of this capacitor. (5)
- [10]

**QUESTION 2: 30 minutes***(Taken from the GDE Preliminary Examination September 2009 Paper 1)*

- 2.1 Capacitors are widely used in common household electrical appliances like television screens, computers, alarm systems etc.
- 2.1.1 What is the function of a capacitor in an electrical appliance. (2)
- 2.1.2 A specific capacitor stores a maximum of 30 nC of charge at a potential difference of 12 V across the ends. Calculate the capacitance of this capacitor. (3)
- 2.1.3 During an electrical thunderstorm the potential difference between the earth and the bottom of the clouds can be 35 000 kV. If the surface area of the clouds is  $1 \times 10^8 \text{ m}^2$  at a height of 1 200 m above the surface of the earth, calculate the capacitance of this gigantic "earth-cloud" capacitor. (4)  
Take the permittivity of air to be the same as the permittivity of a vacuum.

- 2.2 Two point charges with magnitudes of  $+50 \mu\text{C}$  and  $-40 \mu\text{C}$  respectively, are placed at a distance of 450 mm from each other on isolated stands as shown in the diagram below. The charges are allowed to touch each other and are then placed back at their original positions.



- 2.2.1 Calculate the magnitude and nature of each of the charges after they have touched each other, and have been moved back to their original positions. (2)
- 2.2.2 Draw a sketch of the electric field pattern which results after the two charges have touched each other. (4)
- 2.2.3 Determine the magnitude and direction of the force which the charges exert on each other after touching each other. (4)
- 2.2.4 The original force which existed between the two charges before touching each other was 80 times greater than the final force between the two charges after touching. Explain why? (3)

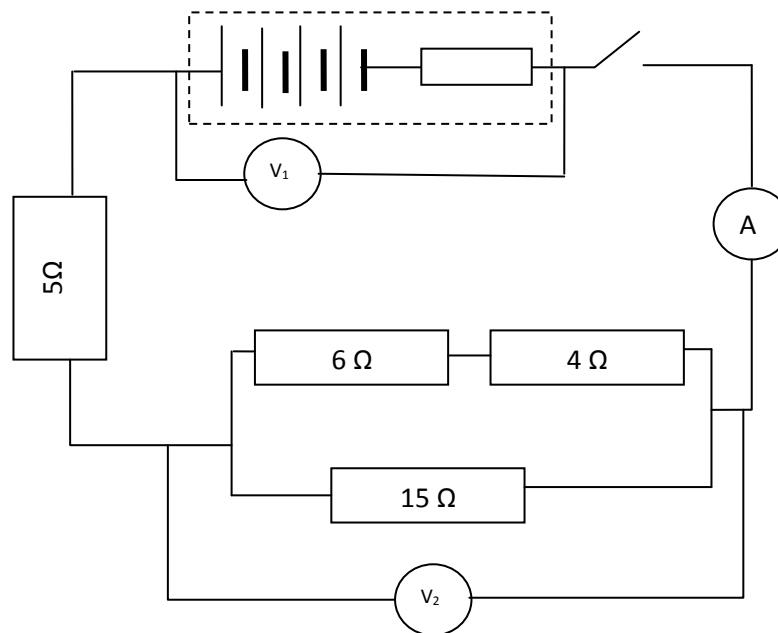
[22]



## TOPIC 2: ELECTRICITY - GRADE 11 REVISION

**QUESTION 3: 25 minutes***(Taken from the GDE Preliminary Examination September 2009 Paper 1)*

- 3.1 The circuit on the following page shows a battery consisting of four 1.5 V cells connected in series. An ammeter with negligible resistance is connected in series to the battery. The reading on the ammeter is 0.5 A when the switch is closed. The connectors have negligible resistance and the voltmeters have very high resistance. Voltmeter  $V_1$  has a reading of 5.5 V when the switch is closed.



- 3.1.1 Calculate the value of the internal resistance of a single cell. (4)
- 3.1.2 Calculate the value of the resistance of the external circuit. (4)
- 3.1.3 Calculate the value of the reading on voltmeter  $V_2$ . (4)
- 3.2
- 3.2.1 A small submersible element takes a certain time to boil a single cup of water. If a similar element of lower resistance, plugged into the same plug, is also used to boil a single cup of water, it takes a shorter time. Explain, using electricity concepts (current, voltage, work done, heat and power), why the water boils faster when the resistance of the element is decreased. (3)
- 3.2.2 Two learners, namely Bongani and David, want to design an investigation to prove the assumption made in 3.2.1.
- 3.2.2.1 Design a method that they will be able to use. List the most important steps – at least five steps – that they need to carry out in order to end up with reliable results. Ensure that you mention in your steps at least one safety precaution that Bongani and David have to take. (3)

- 3.2.2.2 List the controlled variables, the dependant variable and independent variable that Bongani and David have to consider to ensure that the results to their investigation is valid. (2)
- [20]

## SECTION B: ADDITIONAL CONTENT NOTES

### TOPIC 1: ELECTROSTATICS

#### Recall

There are two types of charges:

- Positive – when a substance has lost electrons.
- Negative – when a substance has gained electrons.

#### Electric Fields

- **an electric field** is a region in space in which an electric charge will experience a force represented by a pattern of field lines.
- An electric field line is a line drawn in such a way that at any point on the line a small positive point charge placed at that point will experience a force in the direction of the tangent of the line.

#### Conservation of charge

- The **Law of Conservation of Charge** states that charges cannot be created nor destroyed, but are merely transferred from one object to another, i.e. the amount of charges in a closed system remains the same.
- According to the law, when two charged spheres of the same size are brought into contact, electrons move from the more negative sphere to the less negative sphere till the charge is spread evenly over both spheres. On separation, each sphere carries half the total charge of the two spheres.

#### Coulomb's Law of Electrostatics

***The law states that the force of attraction or repulsion between the two electric charges at rest is directly proportional to the product of the charges, and inversely proportional to the square of the distance between them.***

$$F = \frac{KQ_1Q_2}{r^2}$$

Q = charge, unit: coulomb (C)      r = distance between the charges, measured in m

k = Coulomb's constant =  $9 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$

## Electric Field Strength Introduction

- The measure of the force (attraction or repulsion) exerted on a charge placed at a point in the field.
- By definition:  
***Electric Field strength is the force per unit charge which a positive charge will experience at that point i.e. force experienced by 1C of charge in an electric field.***

**Formula:** Electric Field Strength (E) =  $\frac{\text{Force (F)}}{\text{Charge (q)}}$

**In symbols:**  $E = \frac{F}{q}$

Units: Force – Newton (N), charge – coulomb (C), Field Strength – N/C

- Electric field strength is a vector.
- Therefore, the magnitude of the force exerted on a known charge in an electric field strength:

$$F = QE$$

## Electric Field Strength around a charged sphere

- Consider a small test charge  $q$  placed at distance  $r$  from the charge  $Q$ .
- According to Coulomb's Law, the force  $F$  exerted on  $q$  is given by

$$F = \frac{kQq}{r^2}$$

- If the electric field strength due to  $Q$ , at the point where  $q$  has been placed, is  $E$ , the force  $F$  exerted on  $q$  by the field is

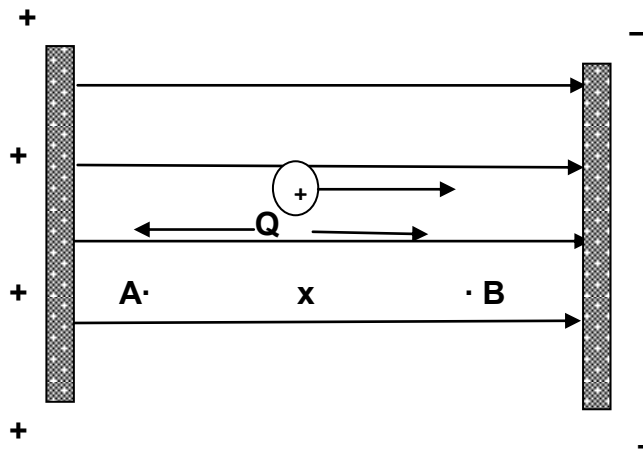
$$F = QE$$

- Combining the two equations:  $\frac{kQq}{r^2} = QE$

- Therefore,  $E = \frac{kQ}{r^2}$

## Work done in moving a charge in an electric field

Consider the following diagram



The point charge  $Q$  experiences a force  $F$  in the direction of the field  $E$ , and if  $Q$  is free to move, it will accelerate in the direction of the field.

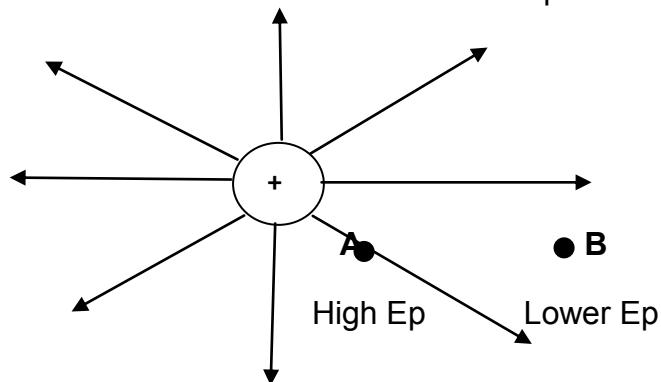
Field exerts a force on  $Q$ , causes it to move therefore work is done on  $Q$ .

$$W = F \cdot x \quad \text{and} \quad F = QE$$

Therefore,  $W = QEs$

## Electrical Potential Difference

- A charge placed at any point in an electric field possesses potential energy.
- When it moves, it accelerates, so its potential is converted to kinetic energy.
- Consider an electric field around a positive sphere



- If a positive charge  $Q$  is placed at point A, it experiences a force of repulsion and moves to the right, gaining kinetic energy as it moves.

- At A the test charge has potential.
- Same charge placed at point B, has the same behaviour.
- To move the charge from B to A requires an external force, i.e. work must be done by an outside force.

- This implies that  $Q$  has more potential energy at point a than at point B.
- Therefore A has a higher electrical potential energy than B and a difference in potential energy exists between these two points.
- *The **potential energy** in an electric field is defined as the work it takes to move a unit positive charge from the point at lower potential to the point at higher potential.*

$$V = \frac{W}{Q}$$

Units: V – volts (v), W – joule (J)

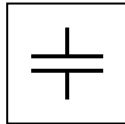
## Electric Field Strength Between two charged parallel plates

- The electric field strength between 2 oppositely charged parallel plates is uniform, i.e. a charge placed anywhere between these plates will have a constant force acting on it.
- The potential difference between the plates is given by :  $V = W/Q$
- Work done by the field is therefore:  $W = QV$
- Work is also :  $W = QEx$
- Therefore,  $QEx = QV$
- The electric field strength  $E = V/d$  where d is the distance between the plates in m.

## Capacitors

- A **capacitor is a device that can store energy**. Like a cell, it has two terminals. Inside a capacitor the terminals connect to two metal plates that are separated by an insulating material called a **dielectric**. The dielectric can be anything that does not conduct electricity readily and it keeps the plates from touching each other.
- The bigger the area of the plates, the more charge the capacitor can store.

- Symbol:



- When a capacitor is connected to a battery, the plate connected to the negative terminal of the battery accepts electrons from the cell and becomes negatively charged.
- The plate connected to the positive terminal loses electrons to the battery and becomes positively charged.
- Once fully charged, the capacitor has the same potential difference as the battery. The area of the metal plates determines how much charge the capacitor can hold, but the voltage depends on the voltage of the power supply that it is connected to.
- As the voltage decreases, the current and hence the rate of discharge, decreases.
- Four factors affect the ability of the capacitor to store electrical charge. These are
  - The potential difference between the plates
  - The area of the plates
  - The distance between the plates and
  - The insulating substance between the parallel plates.

## Capacitance

- Capacitance is a measure of the ability of a capacitor to store charge.
- The capacitance (C) of a capacitor is the charge stored on its plates per volt of potential difference between the plates.

$$C = Q/V$$

- The units for capacitance is coulomb per volt (C/V) called a **farad (F)**.
- The farad is a very large unit. Typical capacitor are in
  - Microfarads,  $\mu F = 10^{-6}F$
  - Nanofarads,  $nF = 10^{-9}F$
  - Picofarads,  $pF = 10^{-12}F$

## Electrical Discharges: Spark plugs and Lightning

- Lightning flashed and spark plugs produce sparks of a very different size with very different voltages needed. Although they are different in nature, they all require air to be ionised.
- In a thunderstorm, charges build up in clouds due to different movements of air, raindrops and ice.
- When the potential difference between a collection of positive charges and one of negative charges becomes big enough, a lightning flash occurs. This can be between two clouds or between a cloud and the ground.
- A spark or a lightning flash (a very big spark) occurs when the force in the field or some other factor causes electrons to be released and ions formed.
- These then collide with other atoms, producing more positive ions and electrons. In a complex way, these form a conducting path, allowing the spark to happen.
- When lightning strikes in a particular place, the following also happens:
  - The lightning may cause a surge if current along good conducting paths nearby, such as cabling and wire fences. For example, if you are using a landline phone, this surge may cause problems.
  - It may also flash over and strike something nearby in addition to the main strike. For example, if you standing close to a tree and the lightning strikes the tree, you may get struck by the lightning as well.

### Precautions

- Try to be indoors when a thunderstorm is approaching.
- Stay inside a car. It is safe because the metal of the car will mean that the charge can only go on the outside without affecting those inside the car.
- Stay away from a tree or tall objects that are out in the open.
- Use a lightning conductor on your home because it provides an easy passage for the lightning to follow.
- Avoid getting wet during a thunderstorm as any contact with water would make it easier to be struck by lightning.

## TOPIC 2: ELECTRIC CIRCUITS

### Resistance and Ohm's Law

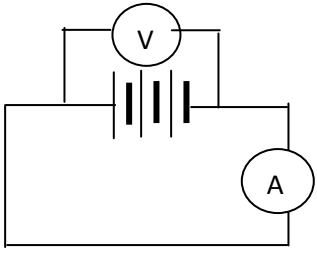
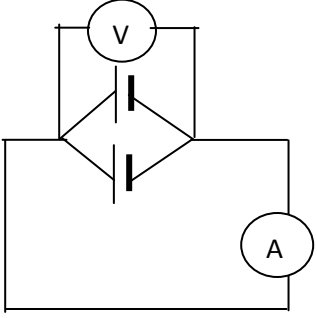
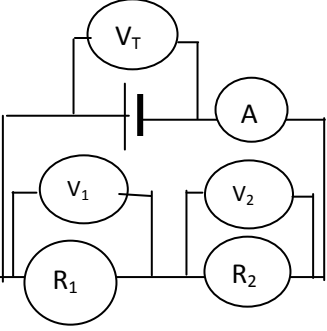
- Ohm's Law states that ***the current between any two points in a conductor is directly proportional to the potential difference between these points provided that the temperature of the conductor remains constant.***

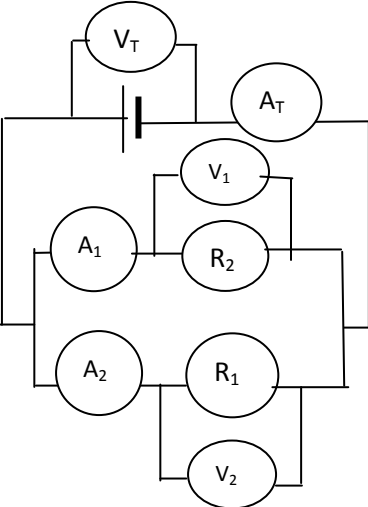
Equation: 
$$R = \frac{V}{I}$$

Units : current – amperes (A), voltage – volts (V) and resistance – ohms ( $\Omega$ )

- The resistance of the conductor depends on
  - The type of material used
  - The length of the conductor – the longer the conductor, the greater the resistance
  - The thickness of the conductor – the thicker the conductor, the smaller the resistance
  - The temperature of the conductor – the higher the temperature, the greater the resistance

**Series and Parallel Connections**

Components	Connection	Diagram	Effect on Current (A)	Effect on Potential Difference (V)
Cells	Series		Increases	Increases
Cells	Parallel		Remains the same	Remains the same
Resistors	Series $R_T = R_1 + R_2$		The current in a given series circuit is the same throughout the circuit.  The more resistors in series, the greater the resistance, the current decreases.	Resistors in series are potential dividers i.e. $V_T = V_1 + V_2$

Resistors	Parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$		Resistors in parallel in a given circuit split the current $A_T = A_1 + A_2$ (the more resistors in parallel, the greater the total current because the total resistance decreases)	Resistors in parallel have the same potential (in the absence of another resistor in series) $V_T = V_1 = V_2$
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### EMF and internal resistance

- The **emf** of a cell is the maximum amount of energy which the cell can supply.
- When the cell is delivering current, the terminal potential difference is less than the emf, the difference is called '**lost volts**' or internal volts .
- The passage of charge through the cell and the **internal resistance** of the cell, account for this loss of energy in the form of heat in the cell.  
Thus emf = terminal potential difference + "lost volts"

$$\text{Emf} = IR + Ir$$

OR 
$$\text{Emf} = I(R + r)$$

Therefore, 
$$I = \frac{\text{emf}}{R + r}$$



## Energy in an electric circuit

### Electrical energy.

#### *Potential difference in an electric field*

- **Potential difference** =  $\frac{\text{work done to move a charge}}{\text{Magnitude of the charge moved.}}$

$$\text{i.e. } V = W / Q, \text{ therefore, } W = Q V$$

- **Quantity of charge** : formula for the quantity of charge is  $Q = I t$   $Q = I \Delta t$

- **Work done by an electric field:**  $W = Q V$   
But  $Q = I t$ ,  $Q = I \Delta t$  therefore,  $W = V I t$   $W = V I \Delta t$

- **Power:** the rate at which work is done  
 $\text{Power} = \frac{\text{work}}{\text{Time}}$

Units: watt (W)

$$\text{If } P = W / \Delta t \text{ and } W = V I \Delta t$$

$$P = \frac{V I \Delta t}{\Delta t}$$

$$\text{Therefore, } P = V I$$

### Ohm's Law and Energy

The formula  $P = VI$  gives the power at which electric energy is 'used' by a device or at which it is supplied by a source.

In summary:

Total amount of work

$$W = V I t$$

But  $V = I R$  (Ohm's Law)

$$W = I^2 R t$$

$$1.1 \text{ Or if } I = V/R$$

$$W = V^2 t / R$$

Power

$$P = VI$$

$$P = I^2 R$$

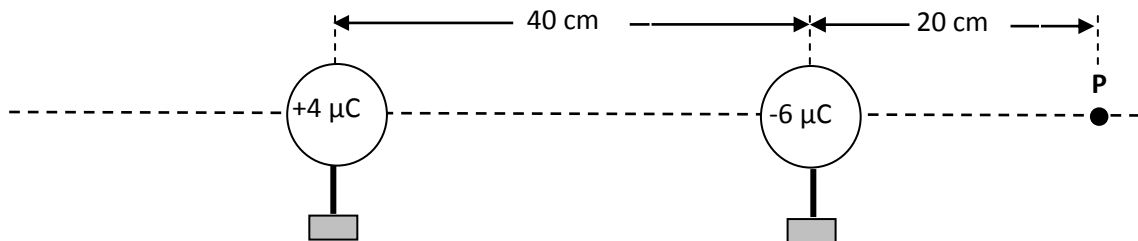
$$P = V^2 / R$$

<b>SECTION C: HOMEWORK</b>
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**TOPIC 1****QUESTION 1: 15 minutes**

*(Taken from the DoE Physical Sciences November Paper 1 2009)*

Two metal spheres on insulated stands carry charges of  $+4 \mu\text{C}$  and  $-6 \mu\text{C}$  respectively. The spheres are arranged with their centres  $40 \text{ cm}$  apart, as shown below.



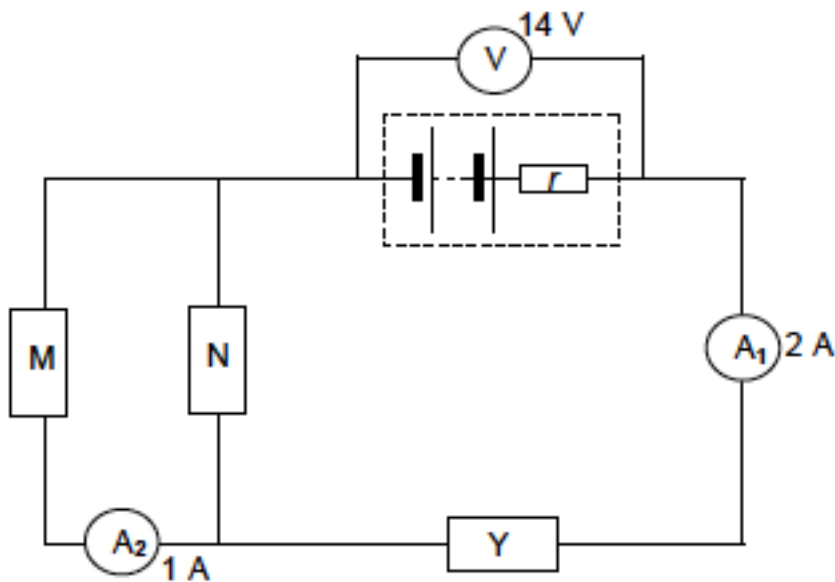
- 1.1 Calculate the magnitude of the force exerted by each sphere on the other. (4)
  - 1.2 By what factor will the magnitude of the force in QUESTION 10.1 change if the distance between the spheres is halved? (Do not calculate the new value of the force.) (1)
  - 1.3 Calculate the net electric field at point P as shown in the diagram above. (6)
  - 1.4 The spheres are now brought into contact with each other and then returned to their original positions. Now calculate the potential energy of the system of two charges. (5)
- [16]

## TOPIC 2

**QUESTION 2: 15 minutes**

(Taken from the DoE Physical Sciences Feb – March Paper 1 2010)

The circuit diagram below shows a battery with an internal resistance  $r$ , connected to three resistors, M, N and Y. The resistance of N is  $2\Omega$  and the reading on voltmeter V is  $14\text{V}$ . The reading on ammeter  $A_1$  is  $2\text{A}$ , and the reading on ammeter  $A_2$  is  $1\text{A}$ . (The resistance of the ammeters and the connecting wires may be ignored.)



- 2.1 State Ohm's law in words. (2)
- 2.2 How does the resistance of M compare with that of N? Explain how you arrived at the answer. (2)
- 2.3 If the emf of the battery is  $17\text{V}$ , calculate the internal resistance of the battery. (5)
- 2.4 Calculate the potential difference across resistor N. (3)
- 2.5 Calculate the resistance of Y. (4)

[16]

## SECTION D: SOLUTIONS AND HINTS TO SECTION A

## TOPIC 1

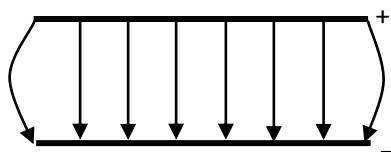
## QUESTION 1

1.1 Dielectric ✓

Distance between plates ✓

(2)

1.2.1



Checklist	Mark
Evenly spaced field lines.	✓
Direction of field lines from positive to negative.	✓
Field lines curved at the ends.	✓

(3)

1.2.2

$$C = \frac{\epsilon_0 A}{d} \checkmark = \frac{(8,85 \times 10^{-12}) \checkmark (2 \times 10^{-2}) \checkmark (10 \times 10^{-2}) \checkmark}{0,2 \times 10^{-3} \checkmark}$$

$$= 8,85 \times 10^{-11} \text{ F } \checkmark$$

(5)

[10]

## QUESTION 2

2.1.1 It stores electrical charge **OR** electric potential energy ✓✓

(2)

$$2.1.2 \quad C = \frac{Q}{V} \checkmark = \frac{30 \times 10^{-9} \checkmark}{12 \checkmark} = 2,5 \times 10^{-9} \text{ F } (= 2,5 \text{ nF}) \checkmark$$

(3)

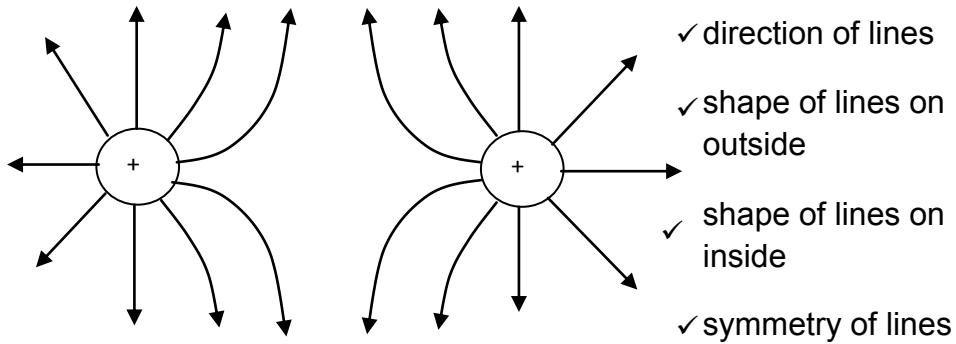
$$2.1.3 \quad C = \frac{\epsilon_0 A}{d} \checkmark = \frac{(8,85 \times 10^{-12}) \checkmark (1 \times 10^8) \checkmark}{1200 \checkmark} = 1,06 \text{ F } \checkmark$$

(4)

$$2.2.1 \quad \text{New charge} = \frac{(+50 \mu\text{C}) + (-40 \mu\text{C})}{2} = +5 \mu\text{C} \quad \checkmark \checkmark$$

(2)

2.2.2



(4)

$$2.2.3 \quad F = \frac{kQ^2}{r^2} = \frac{(9 \times 10^9)(5 \times 10^{-6})^2}{(0.45)^2} = 1.11 \text{ N} \quad \checkmark$$

repulsion  $\checkmark$

(4)

2.2.4 Charges of  $+50 \mu\text{C}$  and  $-40 \mu\text{C}$  became smaller by factors of 10 and 8 respectively. As  $F \propto Q_1 Q_2$ , it means that the original force was  $10 \times 8 = 80$  larger than the final force.  $\checkmark$  (3) [22]

## TOPIC 2

### QUESTION 3

3.1.1

$$r_{\text{battery}} = \frac{V_{\text{used in battery}}}{I_{\text{total}}} = \frac{0.5}{0.5} = 1 \Omega \quad \text{thus each cell} = 1 \Omega / 4 = 0.25 \Omega \quad \checkmark \checkmark$$

(4)

3.1.2

$$\frac{1}{R_p} = \frac{1}{6+4} + \frac{1}{15} = \frac{1}{6} \quad \text{so } R_p = 6 \Omega \quad \text{and}$$

$$R_{\text{external}} = r_1 + r_2 = 5 + 6 = 11 \Omega$$

OR

$$R_{\text{external}} = \frac{V_{\text{external}}}{I_{\text{total}}} = \frac{5.5}{0.5} = 11 \Omega \quad \checkmark$$

(4)

## 3.1.3

$$V_{5\Omega} = IR = 0.5(5) = 2.5V \quad \text{thus}$$

$$V_2 = 5.5 - 2.5 = 3V \quad \checkmark$$

OR

$$V_2 = I_{total} R_p = 0.5(6) = 3V \quad \checkmark$$

(4)

## 3.2.1

$$W = \frac{V^2 t}{R}$$

The same potential difference is applied so that V stays constant. The same amount of water is boiled so the energy W stays the same. This means that  $R \propto t$ . It means that if the resistance decreases  $\checkmark$  then the time to boil the water decreases and the water boils faster.  $\checkmark$

OR

$$P = \frac{V^2}{R}$$

The same potential difference is applied so that V stays constant. This means that  $P \propto 1/R$ . If R decreases then P increases and the time taken to boil the water is less.  $\checkmark$

(3)

## 3.2.2.1

- ❖ Measure identical amounts of water, and place in identical containers at identical temperatures.
- ❖ Place the first submersible element into one of the containers, taking care that there are no open wires in contact with water
- ❖ Start the current and the stopwatch at the same time
- ❖ Note the time it takes to boil the water.
- ❖ Make sure that you handle the hot container with suitable tongs or gloves.
- ❖ Place the second element into the second container of water
- ❖ Start the current and the stopwatch at the same time
- ❖ Note the time it takes to boil the water.
- ❖ Compare the times

✓	Identical amounts of water, Initial temperature the same
✓	Name one safety measure
✓	Measure the time to boil

(3)

## 3.2.2.2 Controlled variables:

- Amount of water
- Same initial temperature
- Same voltage eg plug into 220 V
- Same type of container to control the heating area as well as the conduction of heat.
- Water needs to reach boiling point

Independent variable: The type of element

Dependant variable: Time it takes to boil the water

Any

two

✓ ✓

(2)

[20]

## SESSION 15

## TOPIC: ELECTRODYNAMICS - MOTORS AND GENERATORS AND ALTERNATING CURRENT

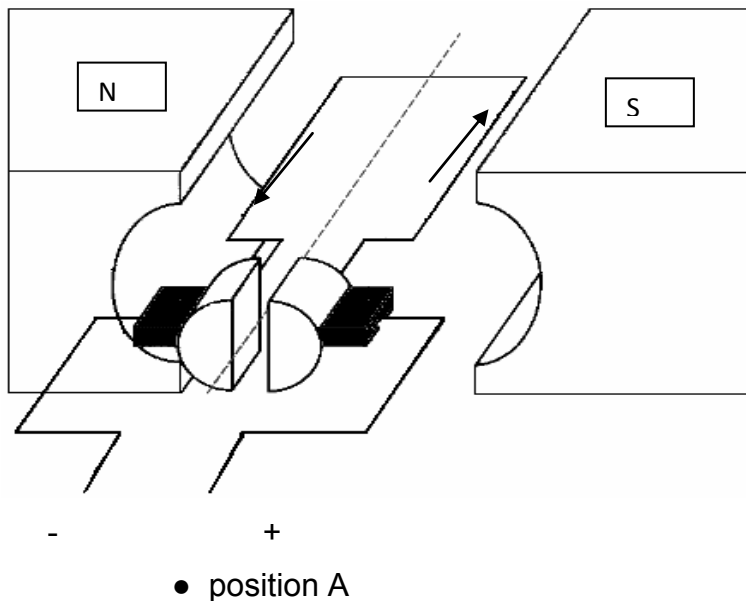
## SECTION A: TYPICAL EXAM QUESTIONS

## QUESTION 1: 13 minutes

(Taken from the DoE Physical Sciences Preparatory Examination Paper 1 2008)

Electric motors are important components of many modern electrical appliances. AC motors are used in washing machines and vacuum cleaners, and DC motors are used in toys and tools.

- 1.1 What energy conversion takes place in electric motors? (2)
- 1.2 What is the essential difference in the design between DC and AC motors? (2)
- 1.3 List THREE ways in which the efficiency of the motor can be improved. (3)
- 1.4 Consider the diagram below. The conventional current flows in the direction indicated by the arrows.



- 1.4.1 In which direction (clockwise or anti-clockwise), as seen from position A, will the coiled armature rotate if the switch is closed? (1)
- 1.4.2 Why does the armature continue moving in the same direction once it has reached the vertical position? (2)

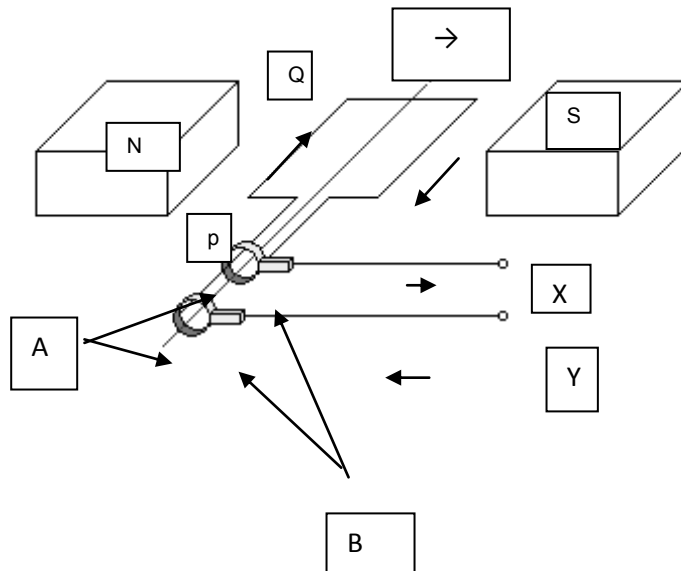
[10]



**QUESTION 2: 10 minutes**

(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The simplified sketch below shows the principle of operation of the alternating current (AC) generator.

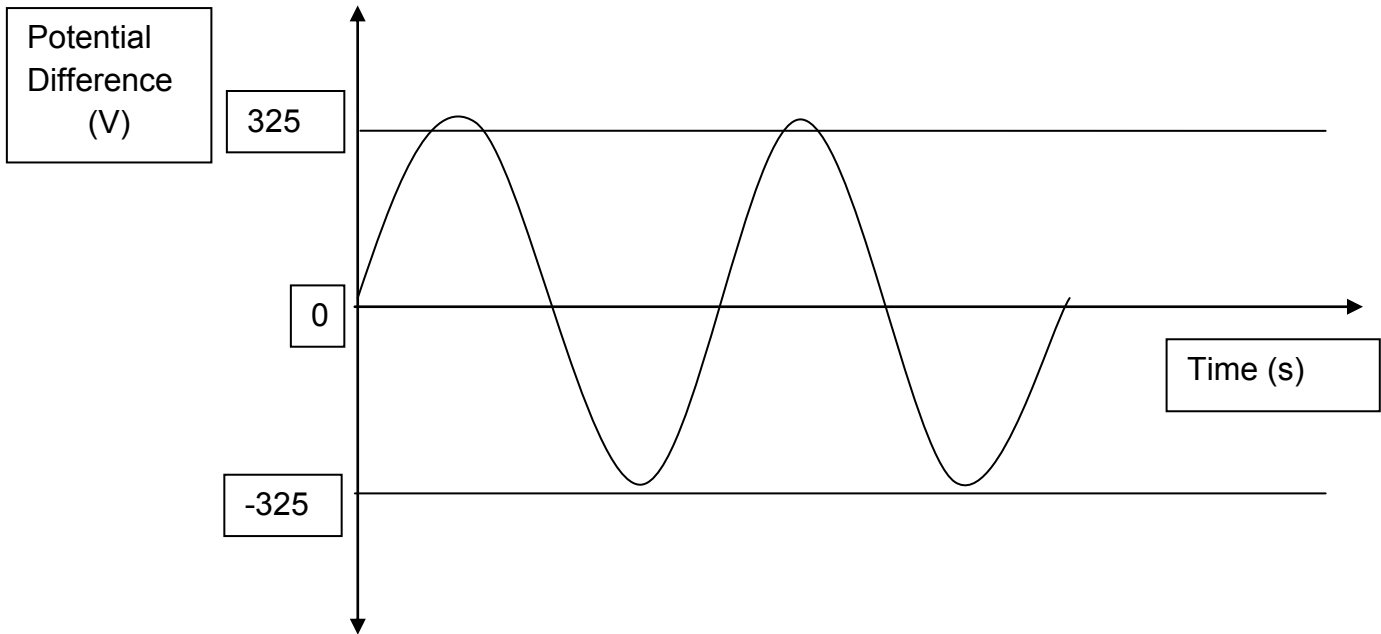


- 2.1 Name the parts labelled A and B respectively. (2)
  - 2.2 In which direction does segment PQ of the coil have to be rotated in order to cause the current direction as shown in the diagram? Write down only clockwise or anticlockwise. (1)
  - 2.3 Write down TWO changes that can be brought about to improve the output of the generator. (2)
  - 2.4 What changes must be made to the AC generator to make it function as a DC motor? (2)
- [7]

**QUESTION 3: 10 minutes**

(Taken from the DoE Physical Sciences Preparatory Examination Paper 1 2008)

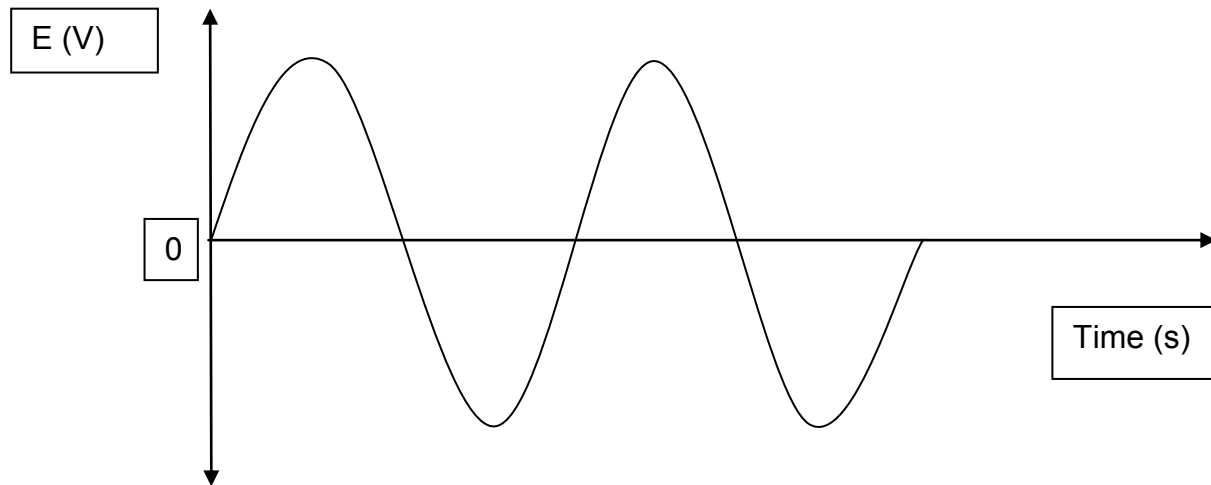
The waveform on the following page is a graphical representation of the variation of voltage (V) versus time (t) for an alternating current.



- 3.1 Explain the advantage of using alternating current at power stations. (2)
- 3.2 Calculate the average power dissipated by this generator if the rms current produced is 13A. (5)  
[7]

**QUESTION 4: 7 minutes**  
(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The induced emf versus time graph for an AC generator is shown below:

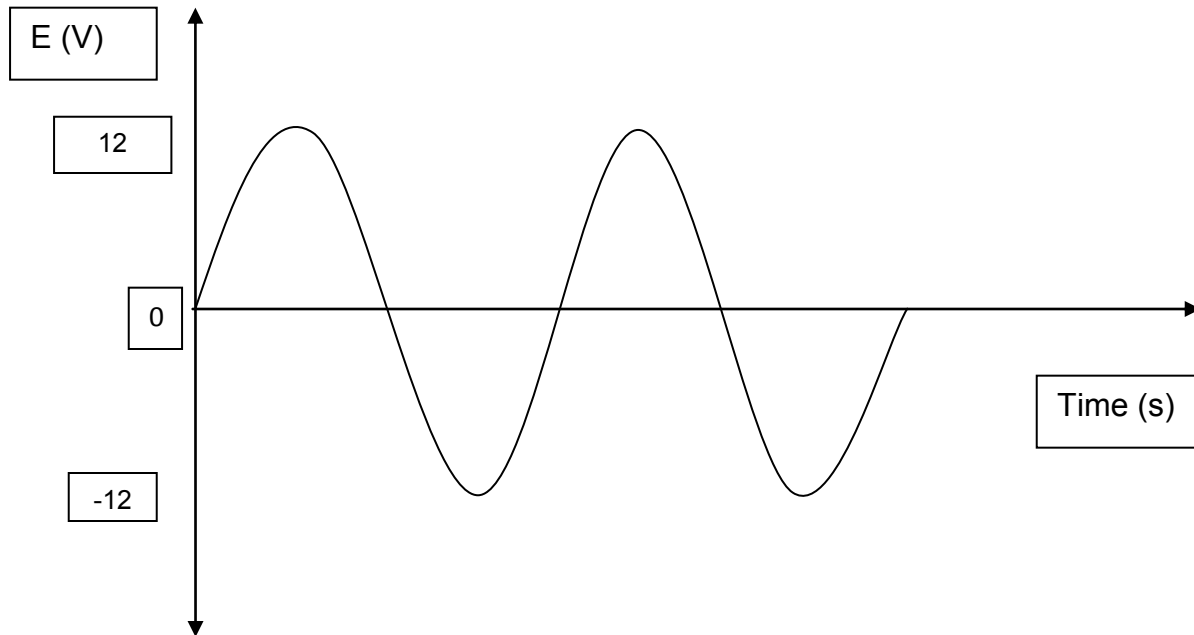


- 4.1 Sketch a graph to show how the above waveform changes, if at all, after changing this generator into a DC generator. (2)
- 4.2 State TWO advantages of using AC over DC for the long-distance transmission of electrical power. (2)  
[4]

**QUESTION 5: 15 minutes**

(Taken from the DoE Physical Sciences Additional Exemplar Paper 1 2008)

The average power of a lamp is 15W. This lamp can be used with either an AC supply or a DC supply. The graph below shows the AC potential difference.



- 5.1 Calculate the potential difference of a DC supply that will produce the same brightness of the lamp. (3)
- 5.2 Calculate the peak current through the lamp when connected to a 12V AC supply.(4)
- 5.3 Draw a sketch graph of current through the lamp against time when connected to the AC supply. Indicate the value of the peak current on the graph. (3)
- [10]

## SECTION B: ADDITIONAL CONTENT NOTES

### The Electric Motor

In order to realise the motor effect, the following components are necessary:

A current needs to be flowing in a magnetic field. This combination of force fields causes movement

Electrical energy is converted into kinetic energy.

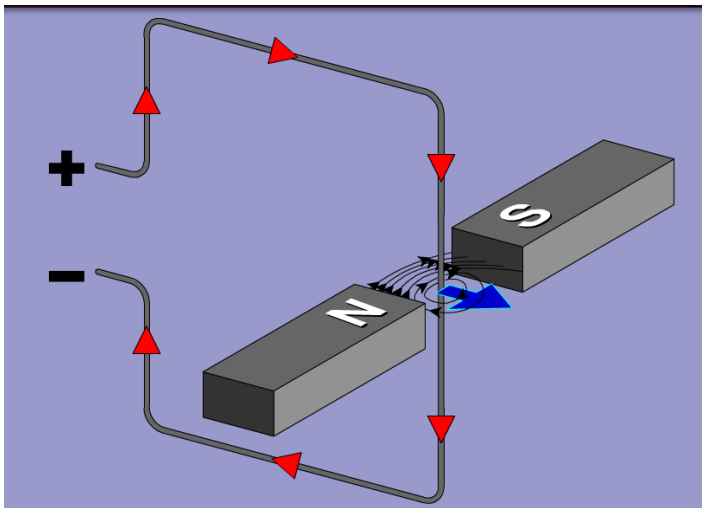


Image taken from Plato Multimedia Science School Simulations 11-16 – Physics – Electric Motor

The direction of the magnetic field is from North to South (N to S)

The current direction is the direction of flow of the conventional current (+'ve to -'ve)



**Fleming's Left Hand Rule** can be used to predict the direction of the force acting on the conductor in a magnetic field.

**Using the LEFT HAND:**

- The first (pointer) finger points in the direction of the field, from North to South.
- The second (middle) finger points in the direction of conventional current, from positive to negative.
- The thumb will then point in the direction of the resultant force.

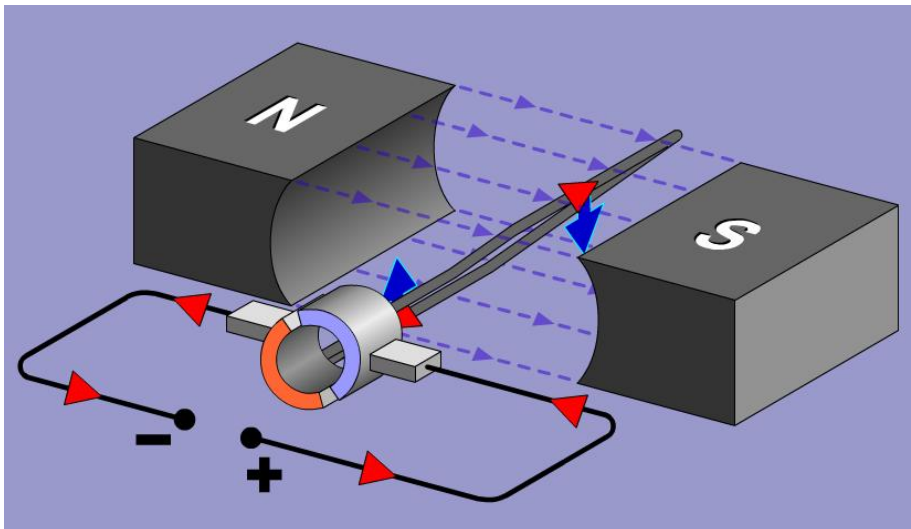
In an electric motor, an electric current passes through the coil in a magnetic field the combination of the two force fields produces a torque which turns the motor.

### Electric current supplied through the commutator.

The commutator reverses the current each half turn to keep the torque turning the coil in the same direction.

The brushes on the commutator allow for the free rotation of the coil.

The left hand rule can be applied to each arm of the rotating coil in order to determine the direction of rotation.



*Image taken from Plato Multimedia Science School Simulations 11-16 – Physics – Electric motor*

If we want to maximise the force created by the motor effect we can:

- Make the current stronger
- Increase the strength of the magnetic field
- Make sure that the angle between the magnetic field direction and the direction of the current is as close to  $90^\circ$  as possible, since the maximum effect is when the current flows at  $90^\circ$  to the magnetic field lines.

### Faraday's Law of Induction

The induced emf in a conductor is directly proportional to the rate of change of the magnetic flux through the conductor.

#### Lenz's Law

The polarity of the induced emf is such that it produces a current whose magnetic field opposes the change which produces it.

### The Dynamo

If a metallic coil is moved in a magnetic field an electric current is induced (created).

An emf is induced across the ends of a coil by a changing magnetic flux, which in turn causes a current to flow.

Kinetic energy is converted into electrical energy

## A DC Dynamo with a split ring and brushes

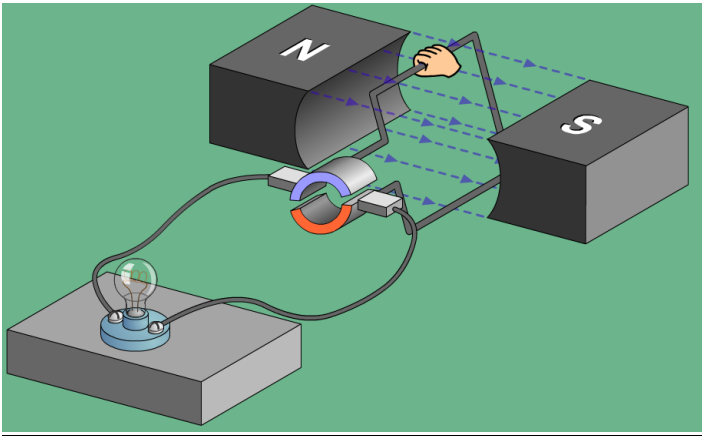


Image taken from Plato Multimedia Science School Simulations 11-16 – Physics – Electric Generator

## An AC Dynamo with slip rings

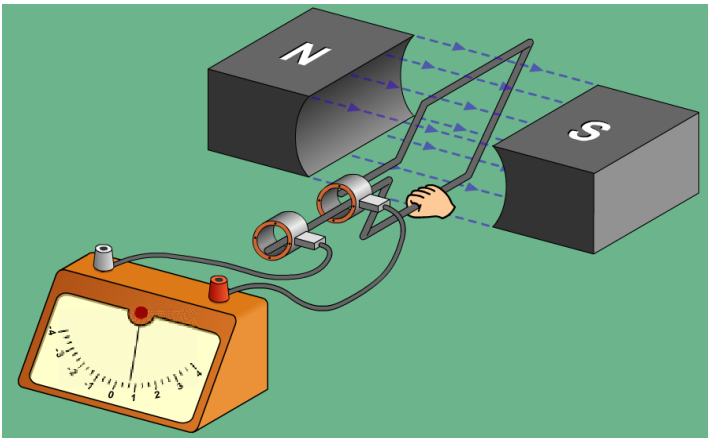
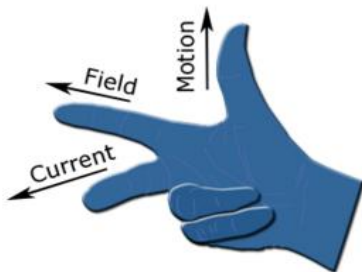


Image taken from Plato Multimedia Science School Simulations 11-16 – Physics – Electric Generator

**Fleming's Right Hand Dynamo Rule** can be used to predict the direction of the induced current.



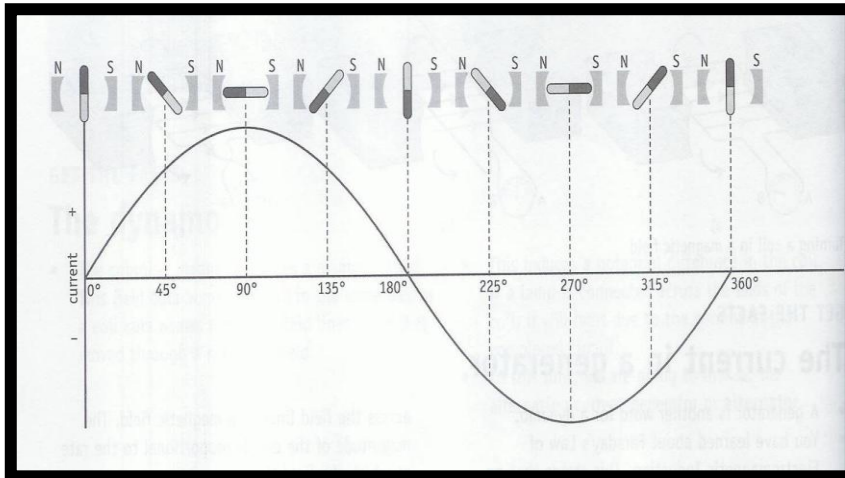
**Using the RIGHT HAND:**

- The first (pointer) finger points in the direction of the field, from North to South.
- The thumb points in the direction of the movement.
- Then the second (middle) finger points in the direction of the induced conventional current, from positive to negative.

## Alternating current

An AC dynamo produces alternating current. Our power stations produce alternating current and the current that we get from the plug points in our homes is AC.

How does the current vary?



The current changes direction every half revolution, and is changing strength continually. This has the advantage of changing the magnetic field in transformers on the national power grid.

Notice the similarity with sine curve.

The frequency of alternating current in South Africa is 50Hz.

The current has a constant potential difference of 220V.

The actual potential difference varies between 0V and 311V. This has the same effect as a constant value of 220V.

$$V_{\text{RMS}} = V_{\text{max}} / \sqrt{2}$$

The current fluctuates with time, in step with the fluctuating potential difference.

$$I_{\text{RMS}} = I_{\text{max}} / \sqrt{2}$$

The average power in an AC circuit is calculated by using:

$$P_{\text{ave}} = V_{\text{RMS}} I_{\text{RMS}}$$

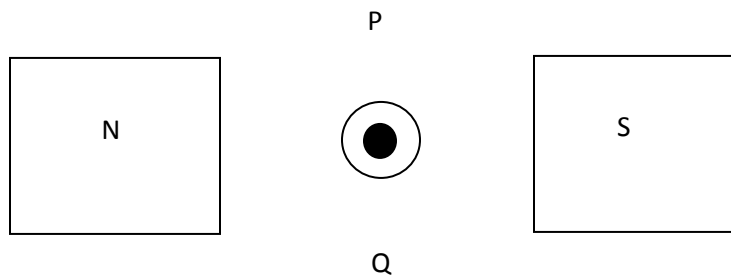
$$P_{\text{ave}} = I_{\text{RMS}}^2 R$$

$$P_{\text{ave}} = V_{\text{RMS}}^2 / R$$

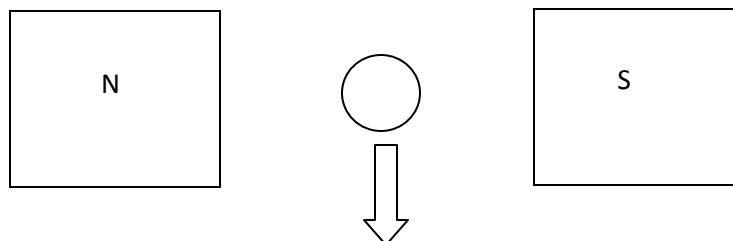
<b>SECTION C: HOMEWORK</b>
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**QUESTION 1: 7 minutes**

- 1.1 Conventional current flows from:
- North to South
  - South to North
  - Positive to negative
  - Negative to positive
- 1.2 Referring to the below aerial sketch of a section of a motor, predict the direction of movement of the conducting wire.



- Towards P
  - Towards Q
  - Into the page
  - Out of the page
- 1.3 Which of the following is not a function of the commutator?
- Supplies electric current
  - Reverses the current each half turn.
  - Stops the current for a split second to allow the coil to rotate.
  - Converts the current into AC
- 1.4 Referring to the aerial sketch of a section of a dynamo below, predict the direction of conventional current in the conducting wire. The arrow represents the applied force.



- Towards North
- Towards South
- Into the page
- Out of the page



1.5 Which of the following energy conversion combinations is correct?

	Motor	Dynamo
A	Electrical to kinetic	Electrical to kinetic
B	Kinetic to electrical	Electrical to kinetic
C	Electrical to kinetic	Kinetic to electrical
D	Kinetic to electrical	Kinetic to electrical

(5 x 2) [10]

**QUESTION 2:**

**13 minutes**

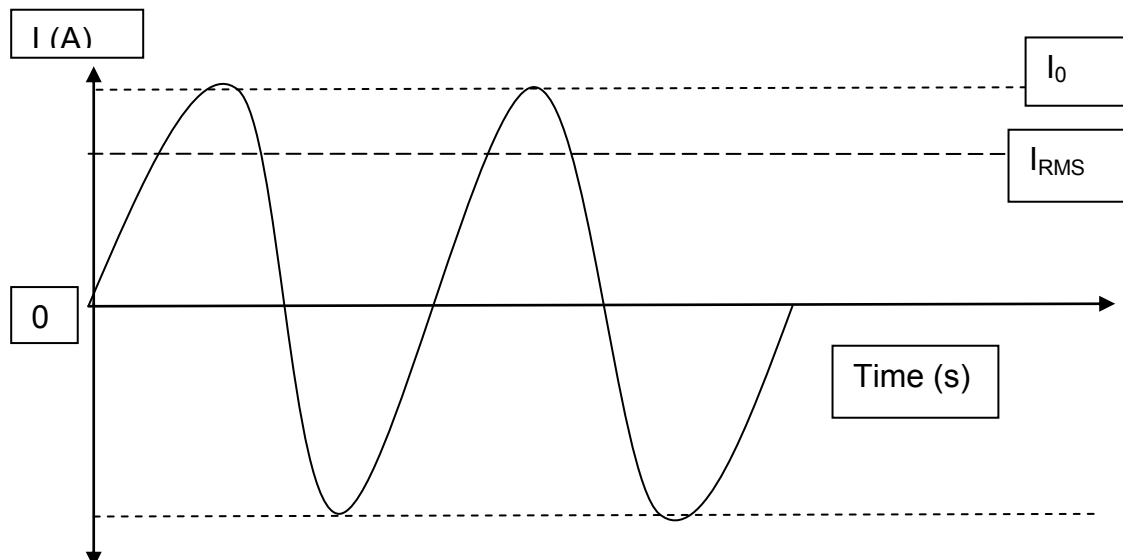
- 2.1 What is the advantage of using more than one coil in the rotor of any motor? (2)
- 2.2 In any motor, what is the function of:
- 2.2.1 commutators? (1)
- 2.2.2 brushes? (1)
- 2.3 Can the speed of a motor be changed without making changes to the motor itself? Explain your answer. (2)
- 2.4 Explain the basic difference between a motor and a generator. (2)
- 2.5 How does Faraday's Law apply to a generator? (2)
- [10]

**QUESTION 3:**

**10 minutes**

(Taken from the DoE Physical Sciences Exemplar Paper 1 2008)

The sine wavefront shown below represents the variation of current ( $I$ ) with time ( $t$ ) for a generator used by a man to light his home. The current alternates between a maximum and a minimum.



In the diagram,  $I_0$  = the peak current,  $I_{\text{RMS}}$  = root mean square current,  $I_{\text{AVERAGE}}$  = average value of the current

- 3.1 Write down an expression for the instantaneous current in terms of the frequency of the source and the time. (2)
- 3.2 Write down a formula which represents the relationship between the maximum peak current ( $I_0$ ) and the root mean square current ( $I_{\text{RMS}}$ ). (2)
- 3.3 The frequency of the AC generated by ESKOM is 50Hz. A sub-station supplies 240V (RMS) to a house. Calculate the peak voltage at a wall socket. (3)
- 3.4 Explain why it is of greater value to use RMS current than the average. (2)
- [9]

## SECTION D: SOLUTIONS AND HINTS TO SECTION A

### QUESTION 1

- 1.1 Electrical energy  $\checkmark$  converted to rotational mechanical energy.  $\checkmark$  (2)
- 1.2. A DC motor reverses current direction with the aid of the commutator whenever the coil is in the vertical  $\checkmark$  position to ensure continuous rotation.  
An AC motor, with alternating current as input, works without commutators since the current alternates.  $\checkmark$  (2)
- 1.3 Increase the number of turns on each coil/increased number of coils  $\checkmark$   
Stronger magnets  $\checkmark$   
Bigger current  $\checkmark$  (3)
- 1.4.1 Clockwise  $\checkmark$  (1)
- 1.4.2 Its own momentum,  $\checkmark$  split ring commutator changes direction  $\checkmark$  of current, every time the coil reaches the vertical position. (2)
- [10]

### QUESTION 2

- 2.1 A = slip rings  $\checkmark$   
B = brushes  $\checkmark$  (2)
- 2.2 anti-clockwise  $\checkmark$  (1)
- 2.3 Any two:  
Increase the number of turns of the coil  $\checkmark$   
Increase the magnetic field strength (stronger magnets)  $\checkmark$   
Increase speed of rotation  
Use horse-shoe magnet –(it helps to concentrate the field) (2)
- 2.5 Use split ring commutators instead of slip rings.  $\checkmark$   
Add a battery to provide electrical energy to drive motor.  $\checkmark$  (2)
- [7]

**QUESTION 3**

3.1 The voltage can be altered by using transformers. ✓ Transformers only operate on AC current. Electrical energy can be transmitted over long distances at low current ✓, and experience low energy loss. (2)

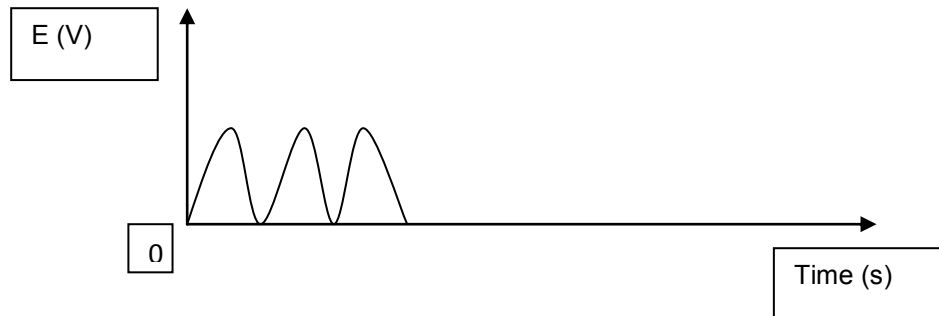
$$\begin{aligned}
 3.2. \quad V_{\text{RMS}} &= V_{\text{max}} / \sqrt{2} \quad \checkmark \\
 &= 325 / \sqrt{2} \quad \checkmark \\
 &= 0,707 (325) = 230 \text{ V}
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{ave}} &= V_{\text{RMS}} I_{\text{RMS}} \quad \checkmark \\
 &= 230 \times 13 \quad \checkmark \\
 &= 2990 \text{ W} \quad \checkmark
 \end{aligned}$$

(5)  
[7]

**QUESTION 4**

4.1 Correct shape ✓ ✓



(2)

4.2 **Any two:**

Easier to generate and transmit from place to place ✓  
 Easier to convert from AC to DC than the reverse ✓  
 Voltage can be easily changed by stepping it up or down  
 High frequency used in AC make it more suitable for electric motors

(2)  
[4]

## QUESTION 5

$$5.1 \quad V_{\text{RMS}} = V_{\text{max}} / \sqrt{2} \quad \checkmark$$

$$= 12 / \sqrt{2} \quad \checkmark$$

$$= 8,49 \text{ V} \quad \checkmark$$

(3)

$$5.2 \quad P_{\text{ave}} = V_{\text{RMS}} I_{\text{RMS}} \quad \checkmark$$

$$15 = 8,49 \times I_{\text{RMS}} \quad \checkmark$$

$$I_{\text{RMS}} = 1,77 \text{ A}$$

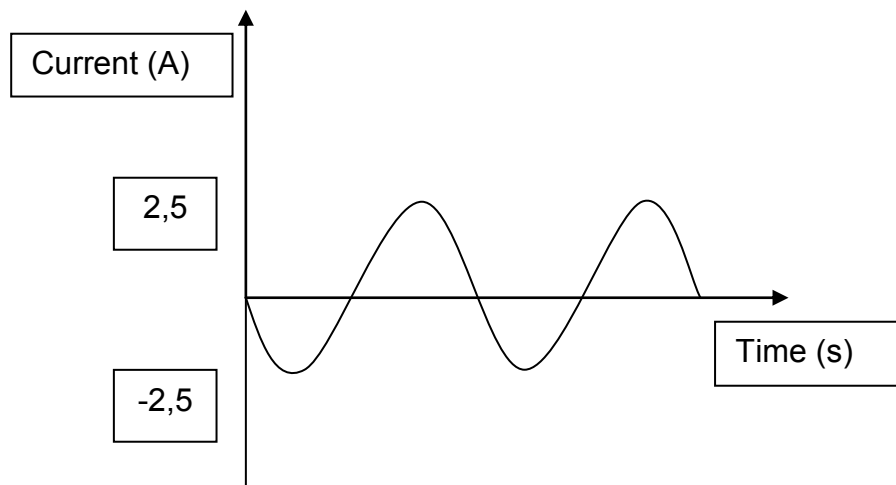
$$I_{\text{RMS}} = I_{\text{max}} / \sqrt{2}$$

$$I_{\text{max}} = 1,77 \sqrt{2} \quad \checkmark$$

$$= 2,5 \text{ A} \quad \checkmark$$

(4)

5.3



Checklist	Marks
Axes drawn and correctly labelled	✓
Shape of graph as indicated	✓
Peak current correctly indicated on y-axis	✓

(3)  
[10]