education

Department:
Education
PROVINCE OF KWAZULU-NATAL

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES P2 (CHEMISTRY)

COMMON TEST

JUNE 2018

MARKS: 100

TIME : 2 Hours

This question paper consists of 9 pages AND 2 data sheets.

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name on the **ANSWER BOOK**.

4. Answer **ALL** the questions in the answer book.

5. You may use a non-programmable calculator.

6. You may use appropriate mathematical instruments.

7. Number the answers correctly according to the numbering system used in this question paper.

8. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEETS.

9. Give brief motivations, discussions, et cetera where required.

SECTION A

QUESTION 1: MULTIPLE- CHOICE QUESTIONS

Four options are provided as possible answers to the following questions.
Each question has only ONE correct answer. Write only the letter (A - D) next to the question number (1.1 – 1.6) in the ANSWER BOOK. e.g. 1.7 A

1.1. Which one of the following is the best explanation for the high degree of solubility of NaCl in water?

A Both molecules are polar.

B Both molecules are ionic.

C The electrostatic forces between the ions in NaCl are of the same order as that of the intermolecular forces in water.

D Water is ionic and NaCl is polar.

(2)

1.2. The factor that does **NOT** affect bond length between two atoms is :

A Size of the atoms.

B Difference in electronegativity between the atoms.

C Number of bonds between the atoms.

D Valencies of the atoms.

(2)

1.3. The phenomenon that allows insects such as mosquitoes to walk on water is:

A Capillarity

B Adhesion

C Surface tension

D Evaporation

(2)

1.4. Which ONE of the following statements regarding the Kinetic Molecular Theory of gases is **INCORRECT**?

A All molecules have the same kinetic energy.

B Gas molecules collide elastically.

C Gas molecules are in random motion.

D Attractive and repulsive forces between the gas molecules can be neglected.

(2)

1.5. The number of **nitrate ions** in 2 moles of $Ca(NO_3)_2$ is:

A $4 \times 6.02 \times 10^{23}$

B $2 \times 6.02 \times 10^{23}$

C 4

D $8 \times 6.02 \times 10^{23}$

(2)

1.6. Consider the combustion of methane gas in a closed rigid container containing $30cm^3$ of oxygen gas.

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

What will be the total volume of gas in the container if $20cm^3$ of oxygen gas reacts with all the methane at a given temperature and pressure?

A $40\ cm^3$

B $30\ cm^3$

C $20\ cm^3$

D $10\ cm^3$

(2)

[12]

SECTION B

INSTRUCTIONS AND INFORMATION

1. Answer all questions.
2. Show the formulae and substitutions in ALL calculations.
3. Round off your numerical answers to a minimum of TWO decimal places.

QUESTION 2

2.1. Use only the substances from the list below when answering questions 2.1.1 to 2.1.7

$HCl_{(g)}$ $HF_{(g)}$ $PH_{3(g)}$ $Cu_{(s)}$ $He_{(g)}$ $KF_{(s)}$ $LiCl_{(aq)}$ $CCl_{4(\ell)}$

Select one substance from the list that has:
(Write only the question number and the Formula of the substance next to it.
You may use a substance more than once).

2.1.1 Pure covalent bonds. (1)

2.1.2 A high melting point due to strong electrostatic attraction between the cations and anions in the crystal lattice. (1)

2.1.3 Hydrogen bonding. (1)

2.1.4 Has dipole-dipole intermolecular forces. (1)

2.1.5 Has ion-dipole forces. (1)

2.1.6 Has a trigonal pyramidal shape. (1)

2.1.7 Has polar covalent bonds, but the molecule is non-polar. (1)

2.2 Consider the table below, which shows the boiling points of the halogens.

Halogen	F_2	Cl_2	Br_2	I_2
Boiling point (°C)	-188	-35	59	184

2.2.1 Name the type of Van de Waal force that exists between molecules of Cl_2. (1)

2.2.2 State the trend in the boiling points of the Halogens. (1)

2.2.3 Explain the trend in question 2.2.2 by making reference to the strength of the intermolecular forces and the energies involved. (3)

2.2.4 Define *vapour pressure.* (2)

2.2.5 Which halogen has the lowest vapour pressure? Give a reason for your answer. (2)

[16]

QUESTION 3

Molecules such as H_2O and HCN are formed by covalent bonding.

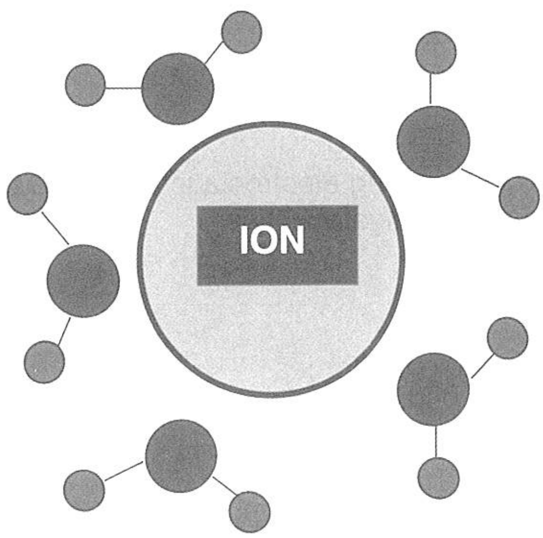
3.1 Define a *covalent bond*. (2)

3.2 Use the VSEPR theory to compare the shape of the water molecule to that of the HCN molecule. (4)

3.3 Draw the Lewis structure for the HCN molecule. (2)

3.4 Water is unique in that its solid state (ice) floats in its liquid state.
Explain fully why ice floats in water. (3)

3.5 Sodium chloride dissolves in water.
The ions are surrounded by water molecules as shown below.

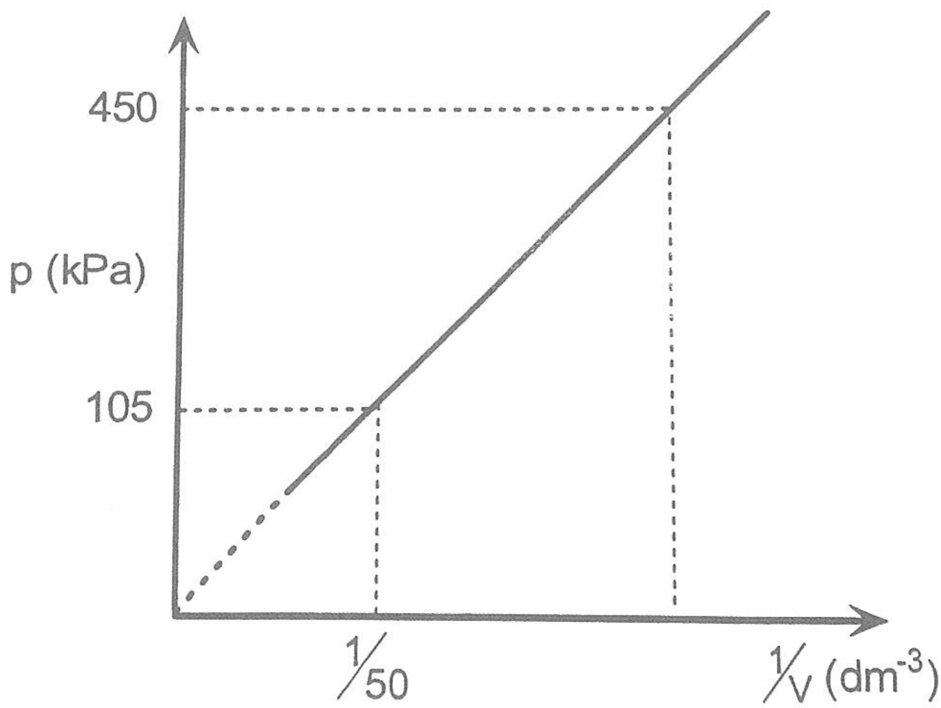


3.5.1 Is the ion shown in the diagram a sodium ion (Na^+) or a chloride ion (Cl^-)? Explain your choice. (2)

3.5.2 A relatively large amount of water is needed to dissolve a small amount of sodium chloride.
Explain why this is so by referring to the structure of sodium chloride and the strength of the forces involved. (3)
[16]

QUESTION 4

The graph below indicates the relationship between the pressure (p) and the reciprocal of volume (1/V) of an enclosed mass of helium (He) gas at 25°C. Assume that helium behaves as an ideal gas.



4.1 Give the name and state in words the Law that is illustrated by the graph. (3)

4.2 Calculate the volume of the He gas at a pressure of 450 kPa. (4)

4.3 Use the graph to calculate the mass of helium that was used. (5)

4.4 Copy the graph in your answer book. Label this graph A.
On the same set of axes draw the graph that will be obtained if:

4.4.1 The experiment is conducted at 35°C (Label this graph B). (2)

4.4.2 A real gas such as ammonia is used instead of helium (Label this graph C). (2)

4.5 Explain fully why the shape of the graph is different in question 4.4.2. (3)

[19]

QUESTION 5

5.1 A grade 11 learner dissolves 13,995 g of $Cu(NO_2)_2$ in water to make up a standard solution with a concentration of 0,15 $mol \cdot dm^{-3}$.

5.1.1 Define a *standard solution.* (2)

5.1.2 Calculate the volume of water (in cm^3) required to prepare this solution. (4)

The learner then transfers some of the above solution to a volumetric flask, and adds 150cm^3 of water to dilute it to a concentration of 0.05$mol \cdot dm^{-3}$.

5.1.3 Calculate the volume of the original solution that must be transferred to the volumetric flask to prepare the diluted solution. (4)

5.2 50g of a substance contains 24,68 g of **K**, 10,13 g of **S** and 15,19 g of **O**.

5.2.1 Define *empirical formula.* (2)

5.2.2 Determine the empirical formula of the compound. (4)

[16]

QUESTION 6

6.1 An **impure** sample containing tin dioxide (SnO_2) is tested to determine how much tin dioxide it contains. The sample weighs 4,50 g.
Excess sulfuric acid is added to the sample and tin (IV) sulfate forms.
The equation for the reaction is:

$$SnO_{2(s)} + 2\,H_2SO_{4\,(aq)} \rightarrow Sn(SO_4)_{2\,(s)} + 2\,H_2O_{\,(\ell)}$$

The mass of tin sulfate produced is 4,90 g.

Calculate the percentage purity of this sample. (6)

6.2 Magnesium burns in oxygen to form magnesium oxide according to the following balanced reaction:

$$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$$

The percentage yield of the reaction is 75%.

Calculate the mass of magnesium that must be burnt in excess oxygen to produce 20 g of magnesium oxide. (6)

6.3 30 g of Al and 1,50 moles of oxygen gas **at STP** are placed in a reaction chamber and allowed to react.
The balanced equation for the reaction is:

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

6.3.1 Explain what is meant by a **limiting reactant**. (2)

6.3.2 Calculate the volume of **excess** oxygen in the reaction chamber. (7)

[21]

TOTAL: 100

TABLE 3: THE PERIODIC TABLE OF ELEMENTS

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29	
Electronegativity / *Elektronegatiwiteit*	1,9 Cu	Symbol / *Simbool*
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5	

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Standard pressure *Standaarddruk*	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	22.4 $dm^3 \cdot mol^{-1}$
Molêre gaskonstante Molar gas constant	R	8.31 $J \cdot K^{-1} \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K
Avogadro's Constant	N of/or N_A	6.022×10^{23} mol^{-1}
Charge on Electron *Lading op elektron*	e	$-1{,}6 \times 10^{-19}$ C

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $pV = nRT$

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MARKING GUIDELINE

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GRADE 11

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This marking guideline consists of 8 pages.

QUESTION 1

1.1. C ✓✓
1.2. D ✓✓
1.3. C ✓✓
1.4. A ✓✓
1.5. A ✓✓
1.6. A ✓✓

6 x 2 = **[12]**

QUESTION 2

2.1

2.1.1 PH_3 ✓ (1)

2.1.2 KF ✓ (1)

2.1.3 HF ✓ (1)

2.1.4 HCl / PH_3 ✓ (1)

2.1.5 LiCl ✓ (1)

2.1.6 PH_3 ✓ (1)

2.1.7 CCl_4 ✓ (1) (7)

2.2

2.2.1 London forces/ induced dipole–induced dipole/ dispersion forces ✓ (1)

2.2.2 As one goes down the group the boiling point increases /
the boiling point increases with an increase in molecular mass ✓ (1)

2.2.3 The molar mass of / no of electrons in the halogens increases from F_2 to I_2. ✓
The strength of the London forces increases. ✓
More energy is needed to separate the molecules /
break the intermolecular forces.✓ (3)

2.2.4 The pressure exerted by a vapour at equilibrium with its liquid
in a closed system✓✓ (2)

2.2.5 I_2✓ – It has the highest boiling point. ✓ (2)

[16]

QUESTION 3

3.1 Sharing of electrons between 2 atoms to form a molecule. ✓ ✓ (2)

3.2 Water has an angular shape✓ whereas hydrogen cyanide has a linear shape.✓
Water has two lone pairs on the central atom whilst hydrogen cyanide has no lone pairs on the central atom. ✓ The repulsion between the lone pairs and bond pairs is stronger than that of the bond pairs and bond pairs, hence giving water an angular shape.✓ (4)

3.3  ✓✓ (2)

3.4 The same mass of liquid water has a smaller volume than that of ice✓ because of (the predominance of) Hydrogen bonding in ice✓,
hence ice has a smaller density than liquid water.✓ (3)

OR

Ice has a lower density than water. ✓ The molecules are loosely arranged in a tetrahedral structure with lots of space✓ within the structure. There are fewer molecules per volume of ice than per volume of water. ✓

3.5

3.5.1 Sodium ion (Na^+).✓ The water molecules are orientated in such a way that the negative ends of the dipoles are attracted by the positive ion. ✓ (2)

3.5.2. The electrostatic force holding the ions in the crystal lattice are much stronger than the ion-dipole forces✓ between ions and the water molecule. Large numbers of water molecules ✓ need to surround the ions in order to overcome the strong electrostatic forces ✓ and pull the ions apart. (3)

[16]

QUESTION 4

4.1 Boyle's Law. ✓
The pressure exerted by an enclosed gas is inversely proportional to the volume ✓ it occupies at constant temperature. ✓ (3)

4.2 $p_1V_1 = p_2V_2$ ✓
105×50✓ $= 450$✓ $\times V_2$
$V_2 = 11.67\ dm^3$ ✓ (4)

POSITIVE MARKING FROM 4.2.

4.3 Gradient = pV

$$= \left[\frac{450-105}{\frac{1}{11{,}67}-\frac{1}{50}}\right] ✓$$

$= 5251.957\ J$

$pV = nRT$✓

$5251.957 = n \times 8.31 \times 298$✓

$n = 2.121 / 2.12\ mol$

$n = m/M$

$2.121 = m/4$ ✓

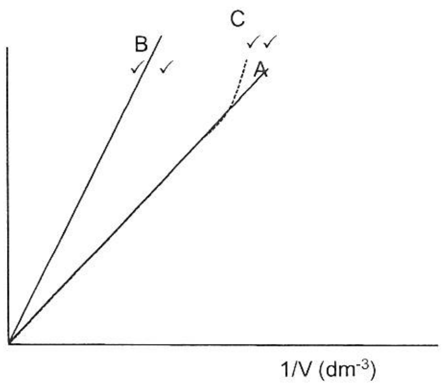
$m = 8.484 / 8.483 / 8.48\ g$ ✓ (5)

$pV = nRT$ ✓
$450 \times 10^3 \times 11.67 \times 10^{-3}$ ✓ $= n \times 8.31 \times 298$✓
$n = 2.121\ mol$

Can use $105 \times 10^3 \times 50 \times 10^{-3}$

4.4.1
4.4.2

P (kPa)



(4)

4.5 At high pressure the gas particles are closer together. ✓ The forces of attraction between the particles become significant and increase. ✓ The gas begins to liquify resulting in an increase in volume. ✓ (3)

[19]

QUESTION 5

5.1

5.1.1 A solution whose concentration is known precisely. ✓✓ (2)

5.1.2 $c = \frac{m}{MV}$ ✓

$0{,}15$ ✓ $= \frac{13.995}{155.5 \times V}$ ✓

$V = 0{,}60\ dm^3 = 600 cm^3$ ✓

OR 5.1.2
n= m/M
= 13,995/155,5 ✓
= 0.09mol
c = n/V
✓any formula
0.15 = 0.09/V✓
V = 0.60dm³ = 600cm³ ✓

(4)

5.1.3 n = c x V
$c_1V_1 = c_2V_2$ ✓ any one

$0{,}15 \times V_1$ ✓= $0{,}05 \times (150 + V_1)$ ✓ (4)

$V_1 = 75\ cm^3$ ✓

5.2

5.2.1 Simplest whole number ratio in which elements in a compound combine. ✓✓ (2)

5.2.2

Element	Mass	n =m/M (mol)	Divide by lowest no	Ratio
K	24.68	24.68/39 = 0.633	0.633/0.317	2
S	10.13	10.13/32 = 0.317 ✓	0.317/0.317 ✓	1 ✓
O	15.19	15.19/16 = 0.949	0.949/0.317	3

Empirical formula is K_2SO_3 ✓ (4)

[16]

QUESTION 6

6.1 $n_{Sn(SO_4)_2} = m/M$ ✓

$= 4.90/311$ ✓

$= 0{,}016$ mol

$M_r = 119 + (32x2) + (8x16) = 311\ g{\cdot}mol^{-1}$

$n_{SnO_4} = n_{Sn(SO_4)_2} = 0{,}016$ mol✓

$n_{SnO_2} = m/M$

$0{,}016 = m/151$✓

$m = 2{,}416$ g

% purity $= \frac{2{,}416}{4{,}50} \times \frac{100}{1}$ ✓

$= 53.69\%$✓

OR 6.1.

$(119 + 32)g\ SnO_2 \rightarrow (119+64+128)g\ Sn(SO_4)_2$

$151g\ SnO_2 \rightarrow 311\ g\ Sn(SO_4)_2$ ✓

$x\ g\ SnO_2$ ✓$\rightarrow 4.90\ g\ Sn(SO_4)_2$ ✓

$x = 2.379\ g\ SnO_2$ ✓

% purity $= \frac{2{,}379}{4{,}50} \times \frac{100}{1}$ ✓

$= 52.87\%$✓

(6)

6.2 **OPTION 1**

$n_{MgO} = m/M$

$= 20/40$ ✓

$= 0{,}50$ mol

No. of moles of MgO required is 0,50 mol

$n_{Mg} = n_{MgO} = 0{,}50$ mol. ✓

$n_{Mg} = m/M$

$0{,}50 = m/24$✓

m = 12 g

12g Mg would be required if the yield was100%

But 12 g Mg gives 75% yield (15g MgO).

Mass of Mg needed for 100% yield (20g MgO):

12 g Mg → 15 g MgO✓

x g → 20 g✓

x = (12/15)x20 = 16 g of Mg required. ✓

OR 6.2

48 g Mg → 80 g MgO✓

x g Mg → 20 g MgO✓

x = (48/80)x20 = 12g✓

12g Mg would be required if the yield was 100%

But 12g Mg gives 75% of 20g = 15g MgO

Then Mg required for 100% yield (20g MgO) is:

12 g Mg → 15 g MgO✓

x g → 20g MgO✓

X = (12/15) x 20 = 16 g Mg required. ✓

(6)

6.2 **OPTION 2**

20 g Mg represents a 75% yield. ✓

Therefore, 100% yield would be 26,667 g. ✓

n_{MgO} = m/M

= 26,667/40 ✓

= 0,667 mol

n_{Mg} = n_{MgO} = 0,667 mol. ✓

n_{Mg} = m/M

0,667 = m/24✓

m = 16 g (16,03 g) ✓ (6)

6.3.1 The reactant that gets used up completely in a reaction. ✓✓ (2)

6.3.2 Criteria for marking.

- Converting 30 g of Al to moles (1,11 mol). ✓
- Establishing that Al is the limiting reagent. ✓
- Applying ratio (4:3) to determine moles of O_2 used. ✓
- Subtracting moles used from initial moles to determine excess moles of O_2. ✓
- Using the formula n = V/V_m ✓
- Substituting 22,4 dm^3 in the above formula. ✓
- Final answer. ✓

OPTION 1

	4Al	+ 3O_2	→ 2Al_2O_3
Ratio	4	3	2
Initial moles	1,11✓	1,5	
Change in moles	1,11✓	0,8325✓	
End moles	0	0,6675✓	

n = V/V_m ✓

0,6675 = V/22.4✓ (7)

V = 14,952 dm^3 ✓

OPTION 2

n_{Al} = m/M

= 30/27
= 1.11 mol ✓ (any one)

n_{O_2} required to react = $\frac{1.11}{4}$ x 3 = 0.8325 mol (< 1.50 mol). ✓

Limiting reactant is Al. ✓

OR

n(O_2) = 1.50 mol

n(Al) required = $\frac{1.50}{3}$x4 = 2 mol (> 1.11 mol)

Limiting reactant is Al. ✓

Therefore, no of moles of O_2 in excess = 1,5 – 0,8325 = 0,6675 mol✓

n = V/V_m ✓

0,6675 = V/22.4✓ (7)

V = 14,952 dm^3 ✓ **[21]**

TOTAL : 100