LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES
CONTROLLED TEST 02
14 SEPTEMBER 2023

MARKS: 100

TIME: 2 hours

This question paper consists of 12 pages including 2 data sheets.

INSTRUCTIONS AND INFORMATION

1. Write your NAME at the TOP of every page on the ANSWER BOOK.
2. This question paper consists of SEVEN questions. Answer ALL questions in the ANSWER BOOK.
3. Start EACH question on a NEW page in the ANSWER BOOK.
4. You may use a non-programmable calculator.
5. You may use appropriate mathematical instruments.
6. YOU ARE ADVISED TO USE THE ATTACHED DATA SHEET.
7. Number the answers correctly according to the numbering system used in this question paper.
8. Give brief motivations, discussions, et cetera where required.
9. Round off your final numerical answers to TWO decimal places.
10. Write neatly and legibly.

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 number (1.1 – 1.10) in the ANSWER BOOK.

1.1 The amount of a substance in a given volume of a solution is…

A Moles
B Concentration
C Molar volume
D Molar mass

(2)

1.2 Ozone decomposes to form oxygen according to the following balanced equation:

$$2O_3(g) \rightarrow 3O_2(g)$$

Which ONE of the changes below is TRUE for the reaction?

A The number of moles increases, but the number of molecules decreases.
B The total number of molecules and moles decreases.
C The number of moles decreases, but the number of molecules increases.
D The total number molecules and moles increases. (2)

1.3 At STP, 1,5 moles of H_2 gas occupies a volume of ...

A 11,2 dm^3
B 22,4 dm^3
C 33,6 dm^3
D 1,5 dm^3

(2)

1.4 The simplest whole number ratio of all elements making up a compound is called…

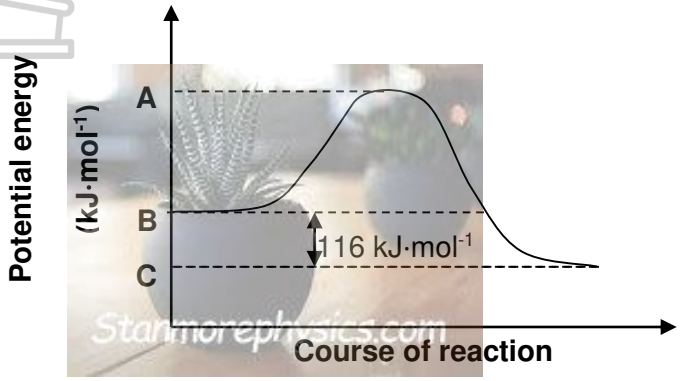
A Molecular formula
B Limiting reactant
C Empirical formula
D Water of crystallisation

(2)

1.5 A barium hydroxide solution, $Ba(OH)_2(aq)$, reacts with a nitric acid solution, $HNO_2(aq)$, according to the following balanced equation:

$$Ba(OH)_2(aq) + 2HNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(\ell)$$

The potential energy graph below shows the change in potential energy for the reaction.



Which of the following combination is CORRECT about the type of reaction and enthalpy change?

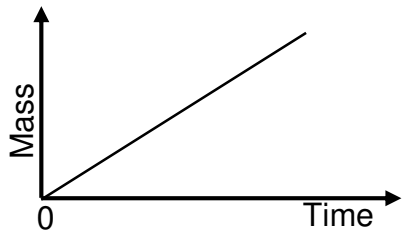
	TYPE OF REACTION	ENTHALPY CHANGE (kJ·mol^{-1})
A	Endothermic	+116
B	Exothermic	−116
C	Endothermic	−116
D	Exothermic	+116

(2)

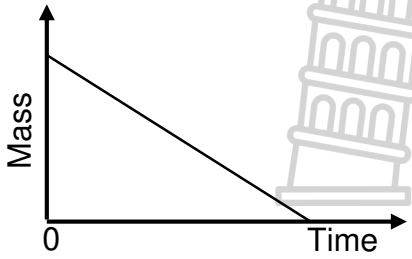
1.6 Manganese dioxide (MnO_2) is used as a catalyst to speed up the decomposition of hydrogen peroxide (H_2O_2) into water and oxygen gas.

Which ONE of the following graphs BEST illustrates the *change in the mass of MnO_2* (**a catalyst**) during this decomposition?

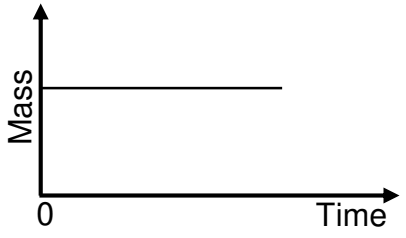
A



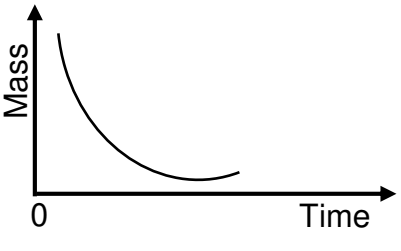
B



C



D



(2)

1.7 Consider the reaction represented below:

$$HC\ell O_2 + H_2O \rightleftharpoons H_3O^+ + C\ell O_2^-$$

Which ONE of the following is a conjugate acid-base pair in the above reaction?

A $HC\ell O_2$ and $C\ell O_2^-$

B $HC\ell O_2$ and H_2O

C $C\ell O_2^-$ and H_3O^+

D $HC\ell O_2$ and H_3O^+

(2)

1.8 Which ONE of the following is a property of an ideal gas?

A Particles occupy the volume due to their motion only.

B The intermolecular forces between the particles are significant.

C The collision between the particles is perfectly inelastic.

D The identical particles maintain their direction when they collide with each other.

(2)

1.9 Which ONE of the following salts will produce a basic solution when dissolved in water?

A Ammonium chloride

B Sodium nitrate

C Ammonium sulphate

D Sodium ethanoate

(2)

1.10 IN the acid-base reaction below:

$$H_2O(\ell) + \mathbf{X}(aq) \rightleftharpoons OH^-(aq) + H_2CO_3(aq)$$

The symbol **X** represents ….

A an acid with the formula CO_3^{2-}

B a base with the formula CO_3^{2-}

C an acid with the formula HCO_3^-

D a base with the formula HCO_3^-

(2)

[20]

QUESTION 2 (Start on a new page)

Ozone (O_3) reacts with nitrogen monoxide (NO) to produce NO_2 gas according to the following balanced equation:

$$O_3(g) + NO(g) \rightarrow O_2(g) + NO_2(g)$$

In the reaction, 1,5 g of O_3 reacts with 1,25 g of NO.

2.1 Define the term *limiting reactant.* (2)

2.2 Determine a substance that is a limiting reactant in the reaction. (6)

2.3 Calculate the:

2.3.1 Mass of NO_2 (g) produced. (3)

2.3.2 Mass of EXCESS reactant when the reaction is complete. (4)

[15]

QUESTION 3 (Start on a new page)

The airbags in cars contain the compound, NaN_3. During a collision, the compound decomposes and nitrogen gas inflates the air bag according to the balanced equation below:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

In one such decomposition, $2,53 \times 10^8$ molecules of nitrogen are formed.

Calculate the:

3.1 Number of mole of NaN_3 (s) which decomposed. (5)

3.2 Volume of N_2 (g) that formed. (4)
Assume that the reaction takes place under standard conditions.

3.3 The percentage of nitrogen atoms in NaN_3. (3)

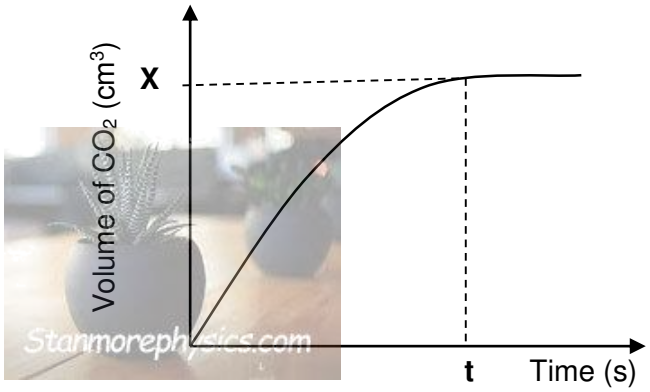
[11]

QUESTION 4 (Start on a new page)

In the chemical reaction, 15 g of an IMPURE sample of calcium carbonate, $CaCO_3$, react with EXCESS hydrochloric acid, HCℓ, of concentration 1,0 mol·dm^{-3} according to the balanced equation below:

$$CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + H_2O(\ell) + CO_2(g)$$

The volume of CO_2 (g) produced is measured and the sketch graph representing the total volume of CO_2(g) produced as a function of time is shown below.



4.1 Define the term *mole of a substance.* (2)

The percentage PURITY of the sample is 90%.

4.2 Calculated the mass of $CaCO_3$ reacted (pure $CaCO_3$). (3)

4.3 Calculate the volume of CO_2 (g) collected (value of **X** on the graph).
Assume that the gas is collected at 25°C and the molar gas volume is 24 dm^3. (6)
[11]

QUESTION 5

Grade 11 learners investigate the relationship between the pressure and volume of an enclosed amount of a gas at room temperature. They recorded the volume of the gas for different pressures in the table below.

PRESSURE (kPa)	VOLUME (cm^3)
40	43
80	27
100	**Y**
120	18

5.1 Write down the NAME and *state* the gas law being investigated. (3)

5.2 For this investigation, write down the:

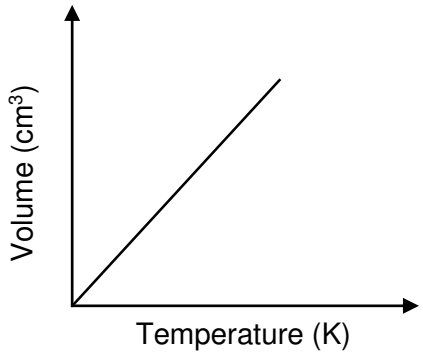
5.2.1 Write down the independent variable (1)

5.2.2 Write down TWO controlled variables (2)

5.3 Calculate the value of **Y** in the table using CONDITIONS at 80 kPa. (4)

5.4 Draw a graph of pressure **p** versus volume **V** on the attached ANSWER SHEET. (3)

5.5 The graph below shows the relationship between volume and temperature for an ideal gas.



5.5.1 Redraw the above graph in the ANSWER BOOK. On the same set of axes, use a BROKEN LINE to sketch the graph that will be obtained for the gas at low temperature. (1)

5.5.2 Fully explain why the gas deviates from ideal behaviour. (3)

5.6 At what pressure will the real gases deviate from ideal gas behaviour*?*

Choose from LOW or HIGH. (1)

[18]

QUESTION 6 (Start on a new page)

Hydrogen gas and oxygen gas react to form water according to the following balanced equation:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) + 241,8\ kJ{\cdot}mol^{-1}$$

The activation energy (E_A) for this reaction is 1370 kJ·mol^{-1}

6.1 Define the term activation energy (2)

6.2 Is the reaction ENDOTHERMIC EXOTHERMIC? Explain your answer. (2)

6.3 Sketch a potential energy versus the course of reaction graph for the above reaction. Clearly label the axis and indicate the following on the graph.

- ΔH
- E_A for the forward reaction
- Reactants (R) and the products (P)
- Activated complex

(6)

6.4 Write down the value of the heat of reaction. (2)

[12]

QUESTION 7 (Start on a new page)

When sulphuric acid reacts with water, it ionises completely in two steps as shown in the two balanced equations below:

I. $H_2SO_4(aq) + H2O(\ell) \rightarrow H_3O^+(aq) + HSO^-_4(aq)$

II. $HSO_4^-(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + SO^{2-}_4(aq)$

7.1 Define *Lowry-Brønsted acid* (2)

7.2 In reaction I, write down the conjugate acid-base pairs. (2)

7.3 Write down the FORMULA of a substance that acts as an ampholyte. (1)

In a titration experiment, 25 cm^3 of sulphuric acid is neutralised by 20 cm^3 of sodium hydroxide solution with concentration of 0,5 mol·dm^{-3}.

Phenolphthalein is added into sulphuric acid solution as an indicator.

7.4 Write down ONE word for the underlined phrase. (1)

7.5 What is the purpose of adding phenolphthalein in the solution? (1)

7.6 Write down the balance equation that takes place. (3)

7.7 Calculate the amount of sodium hydroxide reacted. (3)

[13]

TOTAL : 100

DATA FOR PHYSICAL SCIENCES GRADE 11 PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^{θ}	1,013 x 10^5 Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^{θ}	273 K
Charge on electron	e	-1,6 x 10^{-19} C
Avogadro's constant	N_A	6,02 x 10^{23} mol^{-1}

TABLE 2: FORMULAE

$p_1V_1 = p_2V_2$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a v_a}{c_b v_b} = \frac{n_a}{n_b}$	

NCS

THE PERIODIC TABLE OF ELEMENTS

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)
2,1 1 H 1																	2 He 4
1,0 3 Li 7	1,5 4 Be 9											2.0 5 B 11	2.5 6 C 12	3,0 7 N 14	3.5 8 O 16	4.0 9 F 19	10 Ne 20
0,9 11 Na 23	1,2 12 Mg 24											1.5 13 Al 27	1.8 14 Si 28	2.1 15 P 31	2.5 16 S 32	3.0 17 Cl 35,5	18 Ar 40
0,8 19 K 39	1,0 20 Ca 40	1,3 21 Sc 45	1,5 22 Ti 48	1,6 23 V 51	1,6 24 Cr 52	1.5 25 Mn 55	1.8 26 Fe 56	1.8 27 Co 59	1.8 28 Ni 59	1.9 29 Cu 63,5	1.6 30 Zn 65	1.6 31 Ga 70	1.8 32 Ge 73	2,0 33 As 75	2.4 34 Se 79	2.8 35 Br 80	36 Kr 84
0,8 37 Rb 86	1,0 38 Sr 88	1,2 39 Y 89	1,4 40 Zr 91	41 Nb 92	1,8 42 Mo 96	1.9 43 Tc	2.2 44 Ru 101	2.2 45 Rh 103	2.2 46 Pd 106	1.9 47 Ag 108	1.7 48 Cd 112	1.7 49 In 115	1.8 50 Sn 119	1.9 51 Sb 122	2.1 52 Te 128	2.5 53 I 127	54 Xe 131
0,7 55 Cs 133	0,9 56 Ba 137	57 La 139	1,6 72 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	1.8 81 Tl 204	1.8 82 Pb 207	1.9 83 Bi 209	2.0 84 Po	2.5 85 At	86 Rn
0,7 87 Fr	0,9 88 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

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

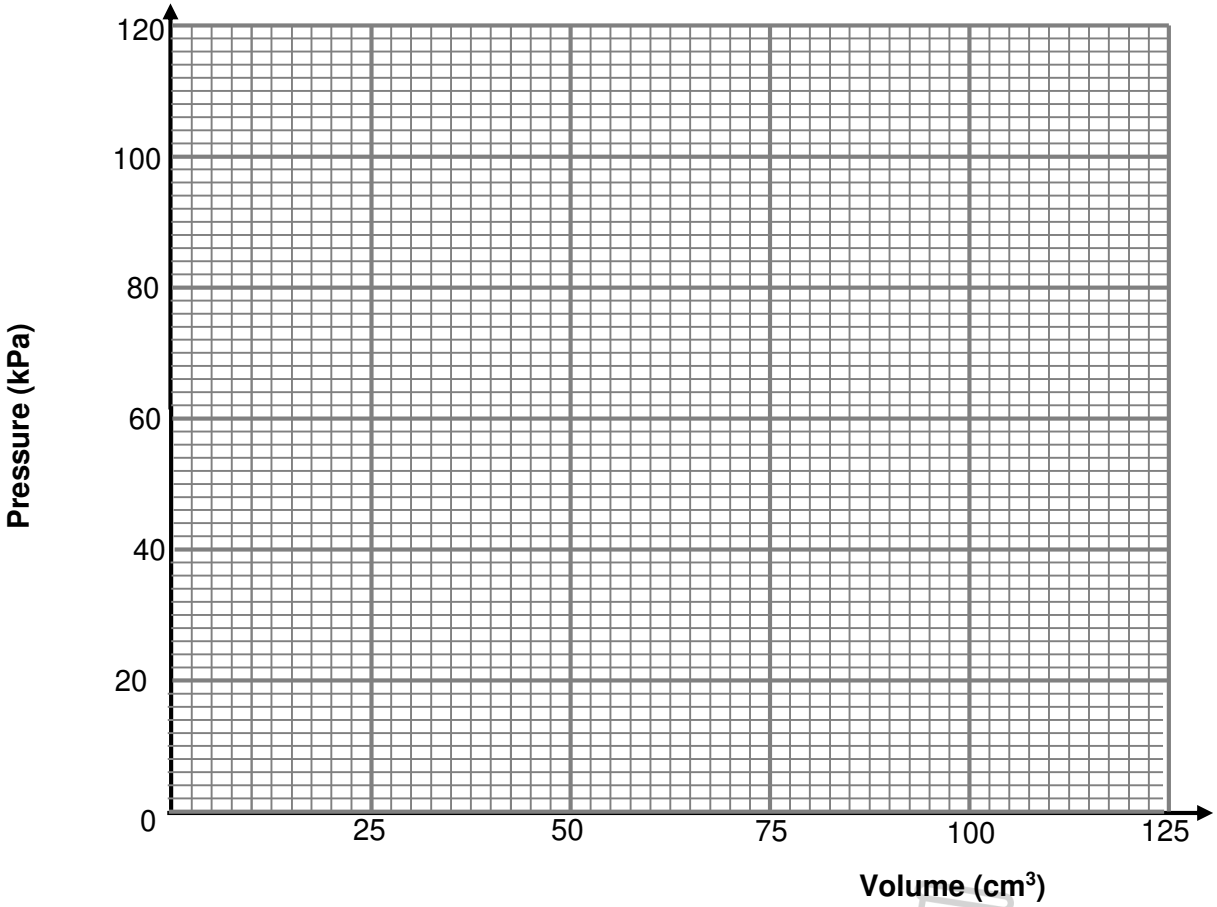
29
1,9 Cu
63,5

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

NAME:	
CLASS:	

Graph of pressure p versus volume V



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GRADE 11

PHYSICAL SCIENCES
CONTROLLED TEST 02
MARKING GUIDELINES

This memorandum consists of seven (7) pages.

QUESTION 1

1.1	B	✓✓	(2)
1.2	D	✓✓	(2)
1.3	C	✓✓	(2)
1.4	C	✓✓	(2)
1.5	B	✓✓	(2)
1.6	C	✓✓	(2)
1.7	A	✓✓	(2)
1.8	A	✓✓	(2)
1.9	D	✓✓	(2)
1.10	D	✓✓	(2)

[20]

QUESTION 2

2.1 The substance that is completely used up (entirely consumed) in a chemical reaction. (2)

2.2 (6)

$n(O_3) = \frac{m}{M} = \frac{1,5}{48}$ ✓ $= 0,03125\ mol$ ✓

$n(NO) = \frac{m}{M} = \frac{1,25}{30}$ ✓ $= 0,04167\ mol$ ✓

$n(O_3)$: n(NO) is1:1

$n(NO)_{reacted} = 0,03125\ mol$ ✓

OR

$n(O_3)_{reacted} = 0,04167\ mol$

∴ O_3 is the limiting reagent. ✓

2.3 2.3.1 $n(O_3)$: n(NO) is 1:1 (3)

$n(NO_2) = 0,03125\ mol$

$n = \frac{m}{M}$ ✓

$0,03125$ ✓ $= \frac{m}{46}$

$= 1,44\ g$ ✓

2.3.2 $n(O_3)$: $n(NO)$ is 1:1 (4)

Δn = 0,04167 – 0,03125 ✓
= 0,01042 mol

$n = \frac{m}{M}$ ✓
$0{,}01042 = \frac{m}{30}$ ✓
∴ m = 0,31 g ✓

[15]

QUESTION 3

3.1

$n = \frac{N}{NA}$ ✓

$= \frac{2{,}53\ X\ 10\text{^}8}{6{,}022\ X\ 10\text{^}23}$ ✓

= 4,20 X 10^{-16} mol ✓

NaN_3: N_2 is 1:1

$n(NaN_3) = \frac{2}{3}(4{,}20\ X\ 10^{-16})$ ✓
= 2,80 X 10^{-16} mol ✓ (5)

3.2 $(N_2) = \frac{V}{V_M}$ ✓

∴ 4,20 X $10^{-16} = \frac{V}{22{,}4}$ ✓

∴ V = 9,41 X 10^{-15} dm^3 ✓ (3)

3.5

M (NaN3) = 23 + 3(14)
= 65 g·mol^{-1} ✓

%N in $NaN_3 = \frac{3(14)}{65} \times 100$ ✓

64.62 % ✓ (3)

[11]

QUESTION 4

4.1 The amount of substance having the same number of atoms as there are atoms in 12g of carbon-12. ✓✓ (2)

4.2 % purity = $\frac{mass\ of\ CaCO3}{mass\ of\ sample} \times 100$

90 ✓ $= \frac{m(CaCO_3)}{15} \times 100$ ✓

$\therefore m(CaCO_3)_{pure} = 13,5\ g$ ✓ (3)

4.3	$n\ (CaCO_3) = \frac{m}{M}$ $= \frac{13,5}{100}$ ✓ $= 0,135\ mol$ ✓ $CaCO_3 : CO_2$ is 1:1 $n(CO_2) = 0,135\ mol$ ✓ $V = nV_m$ ✓ $= (0,135)(24)$ ✓ $= 3,24\ dm^3$ ✓	(6)

[11]

QUESTION 5

5.1 Boyle's Law. ✓ (3)

The pressure of an enclosed amount of gas inversely proportional to the volume of the gas at a constant temperature. ✓✓

5.2 5.2.1 Volume ✓ (1)

5.2.2 Temperature ✓and amount of gas or number of moles✓ (accept mass) (2)

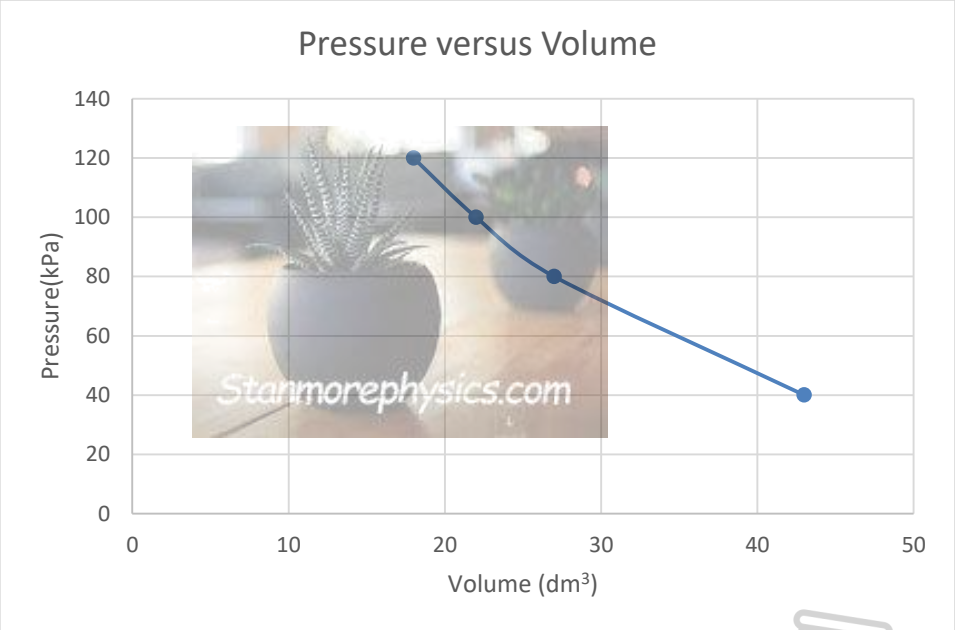
5.3

$p_1V_1 = p_2V_2$ ✓

(80)(27) ✓ = 100(**Y**) ✓ (4)

∴ **Y** = 21,6 cm^3 ✓

5.4

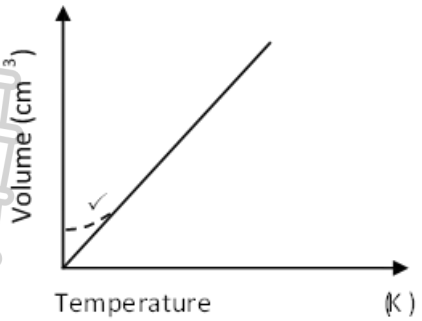


(3)

Marking criteria

- All points plotted ✓
- Line joining all points ✓
- Correct shape (curve) ✓

5.5.1 (1)



5.5.2 At low temperatures, molecules move slower/with less kinetic energy. ✓ (3)
Intermolecular forces become more effective. ✓
The gas liquifies and the volume (open space in container) is larger than predicted for ideal gases.

5.6 HIGH ✓ (1)
[18]

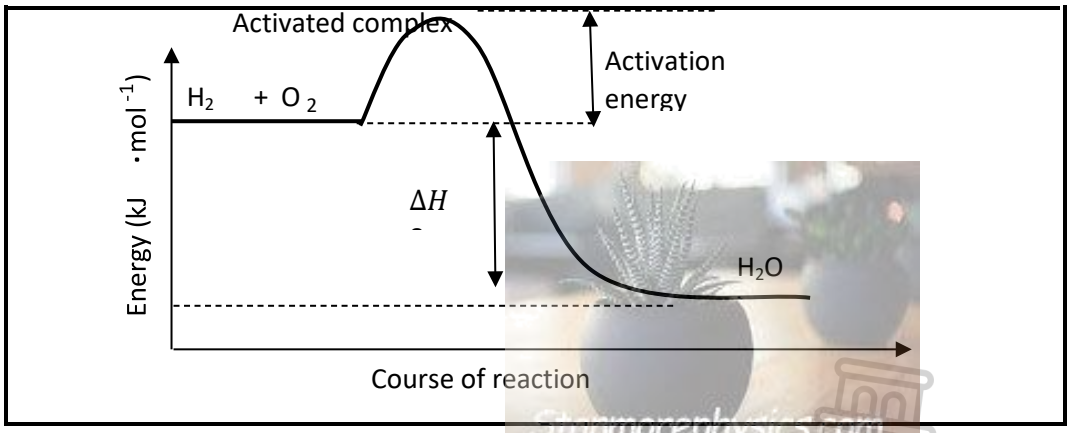
QUESTION 6

6.1 The minimum energy required to start a chemical reaction. ✓ ✓ (2)

6.2 EXOTHERMIC. ✓ (2)
Energy is released or negative enthalpy change ✓

Accept: energy is one of the products.

6.3



(6)

Marking criteria

- Reactants and products ✓✓
- Activated complex ✓
- Heat of reaction ✓
- Activation energy ✓
- Labelling axis ✓

If the graph is endothermmic, max: $^3/_6$

6.4 - 241,8 ✓ kJ.mol^{-1} ✓ (2)
[12]

QUESTION 7

7.1 A proton donor ✓✓ (2)

7.2 • H_2SO_4 and HSO^-_4 ✓ (2)

• H_2O and H_3O^+ ✓

7.3 HSO_4^- ✓ (1)

7.4 Standard solution ✓ (1)

7.5 To determine the equivalence point / indicate the endpoint of the reaction/ show when equal amounts of acid and base have reacted (neutralised). ✓ (1)

7.6 $H_2SO_{4(aq)} + 2NaOH_{(aq)}$ ✓ $\rightarrow Na_2SO_{4(aq)} + 2H_2O_{(\ell)}$ ✓ ✓ (3)

7.7 $c = \frac{n}{V}$ ✓

$0,5 = \frac{n}{0,002}$ ✓

$\therefore n = 0,001$ mol ✓ (3)

[13]

TOTAL: 100