



KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 11

**PHYSICAL SCIENCES
COMMON TEST
SEPTEMBER 2023**

TIME: 2 hours

MARKS: 100



This question paper consists of 8 pages, one graph sheet, and two data sheets.

INSTRUCTIONS AND INFORMATION TO CANDIDATES

1. Write your name on the **ANSWER BOOK**.
2. This question paper consists of **SEVEN** questions. Answer **ALL** the questions in the **ANSWER BOOK**.
3. Start **EACH** question on a **NEW** page in the **ANSWER BOOK**.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Leave **ONE** line between two subsections, for example between **QUESTION 2.1** and **QUESTION 2.2**.
6. You may use a non-programmable calculator.
7. You may use appropriate mathematical instruments.
8. You are advised to use the attached **DATA SHEET**.
9. Show **ALL** formulae and substitutions in **ALL** calculations.
10. Round off your final numerical answers to a minimum of **TWO** decimal places.
11. Give brief motivations, discussions, et cetera where required.



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, for example 1.7 D.

1.1 The number of moles of chloride ions in 111g of calcium chloride, CaCl_2 , is ...

- A 1
- B 2
- C 0,5
- D 1,47

(2)

1.2 Which ONE of the following contains $6,02 \times 10^{23}$ atoms?

- A 18 g of Ar gas.
- B 32 g of O_2 gas.
- C $5,6 \text{ dm}^3$ of NH_3 gas at STP.
- D $22,4 \text{ dm}^3$ of CO gas at STP.

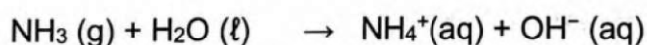
(2)

1.3 Which ONE of the following processes is EXOTHERMIC?

- A Melting of ice.
- B Evaporation of water.
- C Combustion of petrol in a car engine.
- D Reacting a salt in water to form an ice-pack.

(2)

1.4 Consider the following chemical reaction:

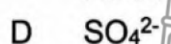
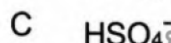


In this equation, H_2O is the ...

- A base because it donates a proton.
- B acid because it accepts a proton.
- C base because it accepts a proton.
- D acid because it donates a proton.

(2)

1.5 Which ONE of the following species CANNOT be an ampholyte?



(2)

1.6 When 50 cm^3 of sulphuric acid, H_2SO_4 , of concentration $0,1 \text{ mol}\cdot\text{dm}^{-3}$ is diluted to a volume of 200 cm^3 , the concentration of the new solution (in $\text{mol}\cdot\text{dm}^{-3}$) will be...

A 0.025

B 0,25

C 0,05

D 0,033

(2)

[12]

QUESTION 2

Aspirin is known by the chemical name acetylsalicylic acid. It is made up of C, H and O only. A sample of aspirin has the following percentage composition:

C	H	O
58,065%	7,527%	

2.1 Define the term *empirical formula*. (2)

2.2 What is the percentage of oxygen in aspirin? (1)

2.3 Determine the empirical formula of aspirin. (5)

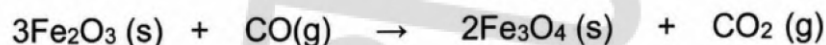
2.4 If the molecular mass of aspirin is $186 \text{ g}\cdot\text{mol}^{-1}$, determine its molecular formula. (2)

[10]

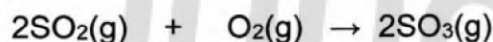


QUESTION 3

- 3.1 A 2,3 kg sample of iron (III) oxide, Fe_2O_3 , is added to 1,7 kg of carbon monoxide (CO) according to the following balanced equation:



- 3.1.1 Define the term *limiting reagent*. (2)
- 3.1.2 Identify the limiting reagent in the reaction by means of a suitable calculation. (5)
- 3.1.3 Calculate the maximum mass of Fe_3O_4 that can be produced. (3)
- 3.1.4 The yield in this reaction was found to be 76%. Calculate the mass of Fe_3O_4 that was actually produced. (3)
- 3.2 The following reaction takes place in a cylinder with a movable lid:



5 volumes of $\text{SO}_2(\text{g})$ and 3 volumes of $\text{O}_2(\text{g})$ are injected into the cylinder at constant temperature.
If the reaction goes to completion, determine the total volume of gas that will be present in the cylinder.

(4)
[17]

QUESTION 4

15g of IMPURE $\text{Mg}(\text{OH})_2$ was reacted with excess phosphoric acid to produce 16g of $\text{Mg}_3(\text{PO}_4)_2$ according to the following balanced equation:



- 4.1 Calculate the percentage purity of the $\text{Mg}(\text{OH})_2$. (5)
- 4.2 If 20g of the same impure $\text{Mg}(\text{OH})_2$ was used in the above reaction, how will each of the following be affected?
Choose from INCREASES, DECREASES or REMAINS THE SAME.
- 4.2.1 The mass of $\text{Mg}_3(\text{PO}_4)_2$ produced. (1)
- 4.2.2 The percentage purity of the $\text{Mg}(\text{OH})_2$. (1)
- 4.3 Explain the answer to Question 4.2.2. (2)



[9]

QUESTION 5

A group of science learners carried out an experiment to verify Boyle's Law for a certain gas. The learners set the pressure to pre-determined values and read off the corresponding volume of the gas for each value of the pressure.

The data collected is shown in the table below. **x**, **y** and **z** represent values in the table.

Pressure (kPa)	Volume (cm ³)	$\frac{1}{\text{Pressure}}$ (x 10 ⁻³ kPa ⁻¹)
142,9	315	7
166,7	270	6
200	225	5
250	180	y
x	135	z

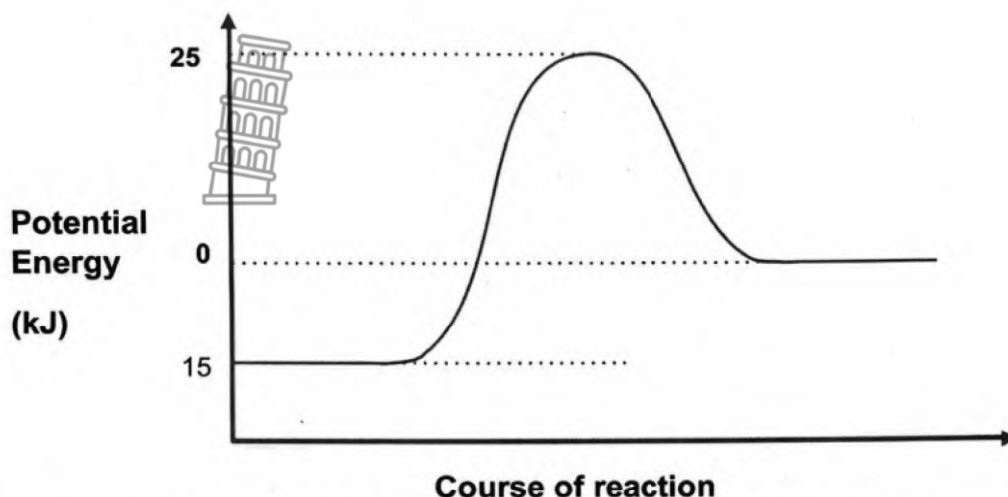
- 5.1 State Boyle's Law in words. (2)
- 5.2 For this experiment, identify the:
 - 5.2.1 Independent variable. (1)
 - 5.2.2 Dependant variable. (1)
- 5.3 State TWO variables that must be kept constant in this experiment. (2)
- 5.4 Calculate the value of **x** in the table. (2)
- 5.5 The above table has been redrawn **above your graph sheet on page 11**.
 - 5.5.1 Fill in the correct values for **y** and **z** in the table. (2)
 - 5.5.2 Using the graph sheet provided, plot a graph of volume (V) verses the inverse of pressure ($\frac{1}{P}$). Be sure to submit this sheet together with your answer booklet. (4)
- 5.6 Write down a suitable conclusion from the graph. (2)
- 5.7 State TWO properties of an Ideal Gas. (2)
- 5.8 State TWO conditions under which real gases deviate from ideal gases. (2)
- 5.9 On the graph that was drawn in QUESTION 5.5.2, draw a sketch to show the deviation of real gas behaviour from ideal gas behaviour (2)

[22]



QUESTION 6

The graph below shows the energy changes for a certain reaction. Study the graph and answer the questions that follow.



- 6.1 Is the reaction EXOTHERMIC or ENDOTHERMIC? Give a reason for the answer. (2)
- 6.2 Define the term *activated complex*. (2)
- 6.3 Write down the value for each of the following:
- 6.3.1 Energy of the reactants (1)
 - 6.3.2 Energy of products (1)
 - 6.3.3 Activation energy for the forward reaction (1)
- 6.4 Calculate the heat of reaction, ΔH . (3)
- 6.5 A catalyst is added to speed up the reaction. What effect will the catalyst have on each of the following?
(Choose from INCREASES, DECREASES or REMAINS THE SAME)
- 6.5.1 Activation energy (1)
 - 6.5.2 The heat of reaction (1)
 - 6.5.3 The energy of the activated complex (1)
 - 6.5.4 Amount of products formed (1)

**[14]**

SECTION 7

A group of learners decide to make a mini volcano by reacting baking soda (NaHCO_3) and acetic acid (CH_3COOH) in a TWO step procedure.

STEP 1

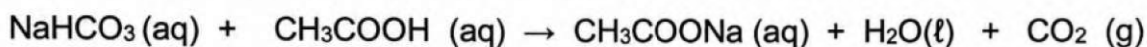
They first prepare a standard solution of NaHCO_3 of concentration $0,2 \text{ mol}\cdot\text{dm}^{-3}$ in a 250 cm^3 volumetric flask.

7.1 Define a *standard solution*. (2)

7.2 Calculate the mass of NaHCO_3 needed to prepare the standard solution. (4)

STEP 2

They then add 50 cm^3 of the standard solution of NaHCO_3 to excess CH_3COOH . The following balanced equation represents the reaction that takes place.



7.3 Define an *Arrhenius acid*. (2)

7.4 Calculate the volume of CO_2 produced. Take the molar gas volume to be $23 \text{ dm}^3\cdot\text{mol}^{-1}$ (4)

7.5 Write down the formula for the:

7.5.1 conjugate acid of CH_3COO^- (2)

7.5.2 conjugate base of HCO_3^- (2)

[16]
TOTAL : 100



DATA FOR PHYSICAL SCIENCES GRADE 11

PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESE KONSTANTES

NAAM/NAME	SIMBOOL/SYMBOL	WAARDE/VALUE
Standard pressure <i>Standaarddruk</i>	p^{θ}	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP <i>Molêre gasvolume teen STD</i>	V_m	$22,4 \text{ dm}^3 \cdot \text{mol}^{-1}$
Standard temperature <i>Standaardtemperatuur</i>	T^{θ}	273 K
Charge on electron <i>Lading op elektron</i>	e	$-1,6 \times 10^{-19} \text{ C}$
Avogadro's constant <i>Avogadro se konstante</i>	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$

TABLE 2: FORMULAE/TABEL 2: FORMULES

$n = \frac{m}{M}$ $n = \frac{N}{N_A}$ $n = \frac{V}{V_m}$	$c = \frac{n}{V} \quad c = \frac{m}{MV}$ $\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$P_1 V_1 = P_2 V_2$
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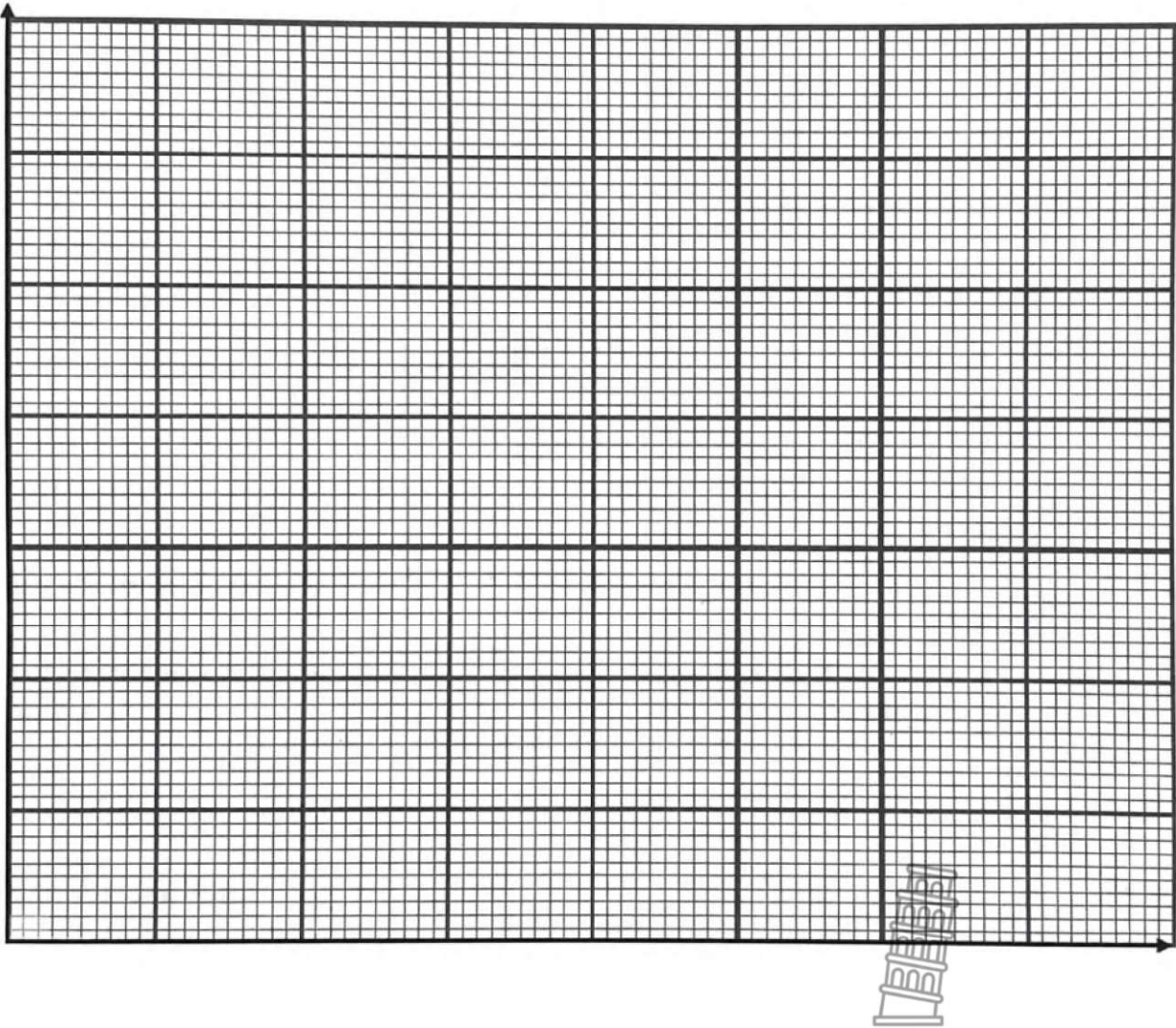
TABLE 3: THE PERIODIC TABLE OF ELEMENTS																																																																																																						
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1 1 H 1,01	2 (II) 4 He 4,00	3 Li 6,94	4 Be 9,01	5 B 10,81	6 C 12,01	7 N 14,01	8 O 16,00	9 F 18,99	10 Ne 20,18	11 Na 22,99	12 Mg 24,31	13 Al 26,98	14 Si 28,09	15 P 30,97	16 S 32,07	17 Cl 35,45	18 Ar 39,95	19 K 39,10	20 Ca 40,08	21 Sc 44,96	22 Ti 47,88	23 V 50,94	24 Cr 52,00	25 Mn 54,94	26 Fe 55,85	27 Co 58,93	28 Ni 58,69	29 Cu 63,55	30 Zn 65,38	31 Ga 69,72	32 Ge 72,64	33 As 74,92	34 Se 78,96	35 Br 79,90	36 Kr 83,80	37 Rb 85,47	38 Sr 87,62	39 Y 88,91	40 Zr 91,22	41 Nb 92,91	42 Mo 95,94	43 Tc 98,91	44 Ru 101,07	45 Rh 102,91	46 Pd 106,42	47 Ag 107,87	48 Cd 112,41	49 In 114,82	50 Sn 118,71	51 Sb 121,76	52 Te 127,60	53 I 126,90	54 Xe 131,29	55 Cs 132,91	56 Ba 137,33	57 La 138,91	58 Ce 140,12	59 Pr 140,91	60 Nd 144,24	61 Pm 144,91	62 Sm 150,36	63 Eu 151,96	64 Gd 157,25	65 Tb 158,93	66 Dy 162,50	67 Ho 164,93	68 Er 167,26	69 Tm 168,93	70 Yb 173,05	71 Lu 174,97	72 Hf 178,49	73 Ta 180,95	74 W 183,84	75 Re 186,21	76 Os 190,23	77 Ir 192,22	78 Pt 195,08	79 Au 196,97	80 Hg 200,59	81 Tl 204,38	82 Pb 207,2	83 Bi 208,98	84 Po 209	85 At 210	86 Rn 222	87 Fr 223	88 Ra 226	89 Ac	90 Th 232,04	91 Pa 231,04	92 U 238,03	93 Np 237,05	94 Pu 244,06	95 Am 243,06	96 Cm 247,07	97 Bk 247,07	98 Cf 251,08	99 Es 252,08	100 Fm 257,10	101 Md 258,10	102 No 259,10	103 Lr 262,11

NAME OF LEARNER : _____

GR 11 _____

Answer sheet for QUESTION 5.5

Pressure (kPa)	Volume (cm ³)	$\frac{1}{\text{Pressure}}$ (x 10 ⁻³ kPa ⁻¹)
142,9	315	7
166,7	270	6
200	225	5
250	180	y
x	135	z





Education

KwaZulu-Natal Department of Education
REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES
MARKING GUIDELINES
COMMON TEST
SEPTEMBER 2023

**NATIONAL
SENIOR CERTIFICATE**

GRADE 11

VERIFIED

NB: This memorandum consists of 8 pages.



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QUESTION ONE

- 1.1 B ✓✓
1.2 C ✓✓
1.3 C ✓✓
1.4 D ✓✓
1.5 D ✓✓
1.6 A ✓✓



[12]

QUESTION TWO

- 2.1 Simplest whole number ratio of atoms in a compound ✓✓ (2)
2.2 Percentage O = $100 - (58,065 + 7,527)$
= 34,408% ✓ (1)

2.3

	C	H	O	
Mass in 100g	58,065g	7,527g	34,408g	✓
$n = m/M$	$\frac{58,065g}{12}$	$\frac{7,527g}{1}$	$\frac{34,408g}{16}$	✓
	= 4,83875	= 7,527	= 2,1505	
Divide by smallest mol	$\frac{4,83875}{2,1505}$	$\frac{7,527}{2,1505}$	$\frac{2,1505}{2,1505}$	✓
Ratio	2,25	3,5	1	
	9	14	4	(5)
Empirical formula	$C_9H_{14}O_4$ ✓✓			

- 2.4 $M(C_9H_{14}O_4) = 9(12) + 14(1) + 4(16)$ ✓
= 186 g.mol⁻¹
∴ molecular formula is $C_9H_{14}O_4$ ✓ (2)

[10]



QUESTION 3

3.1

3.1.1 The reactant that gets finished first / is used up completely in a chemical reaction ✓✓ (2)

NOTE: For questions 3.1.2 and 3.1.3, award marks if ONE table is provided for both questions.

3.1.2 MARKING CRITERIA:

- Formula $n = \frac{m}{M}$
- Substitution for mass(m) and molar mass (M) for Fe_2O_3
- Substitution for mass(m) and molar mass (M) for CO
- Ratio applied correctly 3:1 or 14,375: 4,792
- Final answer: Fe_2O_3

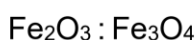
$$\begin{aligned} n \text{ Fe}_2\text{O}_3 &= \frac{m}{M} \quad \checkmark \\ &= \frac{2300}{2(56) + 3(16)} \quad \checkmark \\ &= 14,375 \text{ mol} \end{aligned}$$

$$\begin{aligned} n \text{ CO} &= \frac{m}{M} \\ &= \frac{1700}{12 + 16} \quad \checkmark \\ &= 60,71 \text{ mol} \end{aligned}$$

$$\begin{array}{ccc} n \text{ Fe}_2\text{O}_3 & : & n \text{ CO} \\ 3 & : & 1 \quad \checkmark \end{array}$$

Limiting reagent is Fe_2O_3 ✓ (5)

3.1.3 POSITIVE MARKING FROM QUESTION 3.1.2



$$3 : 2$$

$$14,375 : x$$

$$\begin{aligned} x &= \frac{4,375 \times 2}{3} \quad \checkmark \\ &= 9,58 \text{ mol} \end{aligned}$$

$$\begin{aligned} n (\text{Fe}_3\text{O}_4) &= \frac{m}{M} \\ 9,58 &= \frac{m}{232} \quad \checkmark \\ m &= 2222,56 \text{ g} / 2,22 \text{ kg} \quad \checkmark \end{aligned}$$

$$\begin{aligned} M \text{ Fe}_3\text{O}_4 &= 3(56) + 4(16) \\ &= 232 \text{ g.mol}^{-1} \end{aligned} \quad (3)$$

3.1.4 **POSITIVE MARKING FROM QUESTION 3.1.3**

$$\begin{aligned} \text{Actual mass of Fe}_3\text{O}_4 \text{ produced} &= \frac{76}{100} \checkmark \times 2222,56 \checkmark \\ &= 1689,15 \text{ g} \checkmark \end{aligned} \quad (3)$$



- 3.2 2 vols SO₂ reacts with 1 vol O₂
 5 vols SO₂ reacts with 2,5 vols O₂ to produce 5 vols SO₃ ✓

$$\text{Total volume} = (3-2,5) \checkmark + 5 \checkmark = 5,5 \text{ vols} \checkmark \quad (4)$$

[17]

QUESTION 4

4.1 **MARKING CRITERIA:**

- Substitution of 262 g·mol⁻¹ into formula ($n = \frac{m}{M}$) to convert 16 g of Mg₃(PO₄)₂ to moles. ✓
- Apply ratio of 3:1 for n(Mg₃(PO₄)₂) : n(Mg(OH)₂). ✓
- Substitution of 58 g·mol⁻¹ to calculate mass of pure Mg(OH)₂. ✓
- Substitution into correct formula to calculate % purity. ✓
- Final answer. ✓

$$\begin{aligned} \text{Mg}_3(\text{PO}_4)_2 \text{ produced:} \quad n &= \frac{m}{M} \\ &= \frac{16}{262} \checkmark = 0,061 \text{ mol} \end{aligned}$$

$$\text{Mol of pure Mg(OH)}_2 \text{ used} = 3(0,061) \checkmark = 0,183 \text{ mol}$$

$$\begin{aligned} \text{Mass of Mg(OH)}_2 \text{ used:} \quad m &= nM \\ &= 0,183 \times 58 \checkmark \\ &= 10,614 \text{ g} \end{aligned}$$

$$\begin{aligned} \% \text{ purity} &= \frac{10,612}{15} \times 100 \checkmark \\ &= 70,76 \% \checkmark \end{aligned} \quad (5)$$



4.2.1 Increases. ✓ (1)

4.2.2 Remains the same. ✓ (1)

4.3 The ratio of the mass of pure Mg(OH)₂ in a given sample to the total mass of the sample remains constant. ✓✓ (2)

[9]

QUESTION 5

5.1 The volume of an enclosed mass of (dry) gas is inversely proportional to the pressure when the temperature remains constant. ✓✓ (2)

5.2.1 pressure ✓ (1)

5.2.2 volume ✓ (1)

5.3 Mass (of gas) ✓
 Temperature (of gas) ✓ (2)

5.4 $p_1V_1 = p_2V_2$
 $(250)(180) = (x)(135)$ ✓
 $x = 333,33 \text{ (kPa)}$ ✓ OR ANY VALUES FROM TABLE (2)

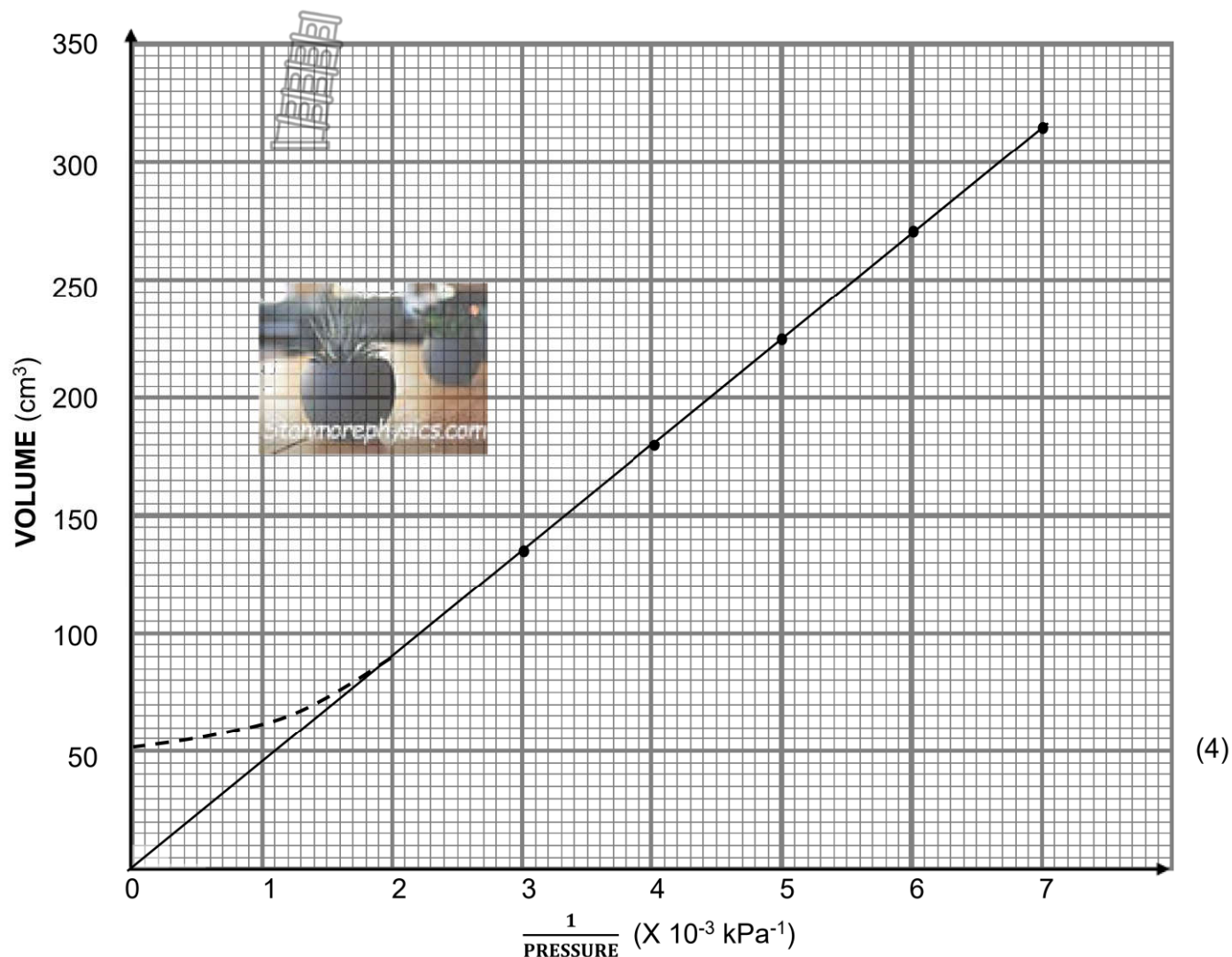
5.5.1 POSITIVE MARKING FROM QUESTION 5.4

Pressure(kPa)	Volume(cm ³)	$\frac{1}{P} (x 10^{-3} \text{ kPa}^{-1})$
142,9	315	7
166,7	270	6
200	225	5
250	180	4✓
333,3	135	3✓

(2)



Graph of Volume vs 1/Pressure



Marking Rubric

	Criteria	Mark
1	Volume on y-axis and Inverse of pressure on x-axis	1
2	All points correctly plotted -1 if more than 2 points plotted incorrectly	2
3	Line of best fit drawn	1
4	Deviation for Question 5.9	2

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Please turn over

- 5.6 Volume is directly proportional to $1/\text{pressure}$ OR $v \propto 1/p$. ✓✓ (2)
- 5.7 Particles: are identical in all respects.✓ / are in a state of random motion.✓
collisions are completely elastic / no force of attraction or repulsion except
when they collide / particles themselves do not have volume. (any two) (2)
- 5.8 High pressure ✓ Low temperature✓ (2)
- 5.9 On graph/ see Rubric✓✓ (2)
- [23]**

QUESTION 6

- 6.1 Endothermic.✓
 $\Delta H > 0$ ✓ / $E_p > E_r$ (2)
- 6.2 The unstable transition state from reactants to products.✓✓ (2)
- 6.3.1 -15 kJ ✓ (Accept 15 kJ) (1)
- 6.3.2 0 (kJ) ✓ (1)
- 6.3.3 40 kJ ✓ (Accept 10 kJ) (1)
- 6.4 $\Delta H = E_{\text{products}} - E_{\text{reactants}}$

$$= \overset{\checkmark}{0} - \overset{\checkmark}{(-15)}$$

$$= +15 \text{ kJ} \checkmark$$

Accept: $0 - 15$
 $= -15 \text{ kJ}$

(3)
- 6.5.1 Decreases.✓ (1)
- 6.5.2 Remains the same.✓ (1)
- 6.5.3 Remains the same.✓ (1)
- 6.5.4 Remains the same.✓ (1)

[14]



QUESTION 7

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

7.2 **OPTION 1**

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

$$0,2 = \frac{m}{(84)(0,25)} \quad \checkmark$$

$$m = 4,2g \quad \checkmark$$

OPTION 2

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

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

$$0,2 = \frac{n}{0,25} \quad \checkmark$$

$$0,05 = \frac{m}{84} \quad \checkmark$$

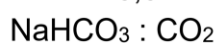
$$n = 0,05 \text{ mol}$$

$$m = 4,2g \quad \checkmark$$

(4)

7.3 Substance that produces hydronium ions (H_3O^+) when dissolved in water. ✓✓ (2)

$$\begin{aligned} n(\text{NaHCO}_3) &= C \times V \\ &= 0,2 \times 0,05 \quad \checkmark \\ &= 0,01 \text{ mol} \end{aligned}$$



$$n \text{ CO}_2 = 0,01 \text{ mol} \quad \checkmark$$

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

$$0,01 = \frac{V}{23} \quad \checkmark$$

$$V = 0,23 \text{ dm}^3 \quad \checkmark$$

(4)

7.5.1 CH_3COOH ✓

(2)

7.5.2 CO_3^{2-} ✓

(2)

[16]

TOTAL: 100

