



KWAZULU-NATAL PROVINCE

EDUCATION
REPUBLIC OF SOUTH AFRICA

**PROVINCIAL STANDARDISED
ASSESSMENT**

GRADE 11

PHYSICAL SCIENCES

SEPTEMBER 2026

MARKS: 100

DURATION: 2 hours

This question paper consists of 11 pages and 2 data sheets.

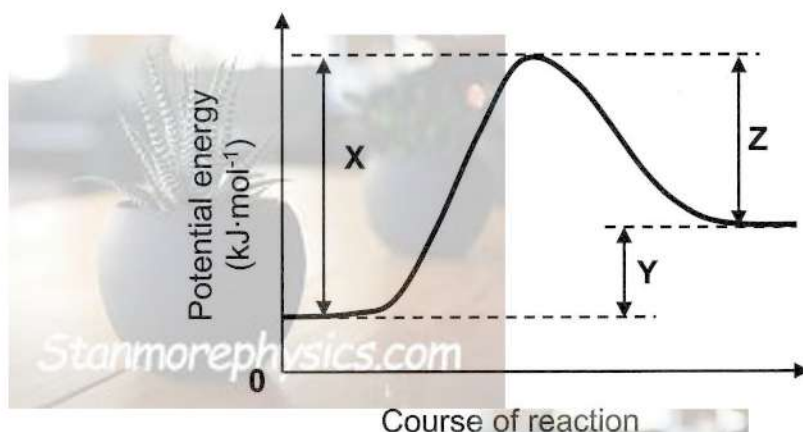
INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions. Answer ALL the questions in the ANSWER BOOK.
2. Start EACH question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line between two sub-questions, for example between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You may use appropriate mathematical instruments.
7. You are advised to use the attached DATA SHEET.
8. Show ALL formulae and substitutions in ALL calculations.
9. Round off your final numerical answers to a minimum of TWO decimal places.
10. Give brief motivations, discussions et cetera where required.
11. 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. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.6) in the ANSWER BOOK, for example 1.7 E.

- 1.1 The energy changes represented by **X**, **Y** and **Z** on the potential energy graph below takes place during a chemical reaction.



Which ONE of the following combinations best describes the effect that the addition of a catalyst will have on X, Y and Z?

	X	Y	Z
A	Increases	Stays the same	Increases
B	Decreases	Stays the same	Decreases
C	Decreases	Decreases	Decreases
D	Increases	Increases	Increases

(2)

- 1.2 Which ONE of the following statements is correct for Avogadro's Law?

- A One mole of any gas occupies the same volume at the same temperature and pressure
- B One mole of any gas occupies the same volume at standard temperature and pressure
- C One mole is the amount of substance having the same number of particles as there are atoms in 12 g carbon-12.
- D Avogadro's number is the number of particles present in one mole.

(2)

1.3 Consider the following statements:



According to Boyle's law, for a fixed mass of gas at constant temperature,

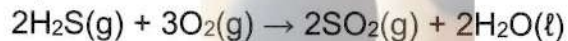
- (i) pressure and volume are directly proportional.
- (ii) if the pressure exerted by the gas is doubled, the volume of the gas is halved.
- (iii) the product of the pressure and volume of the gas remains constant. stanmorephysics.com

Which of the above statements are TRUE?

- A (i) only
- B (i) and (iii) only
- C (ii) and (iii) only
- D (ii) only

(2)

1.4 Hydrogen sulphide, $\text{H}_2\text{S}(\text{g})$, reacts with oxygen, $\text{O}_2(\text{g})$, according to the following balanced equation:



Initially $y \text{ dm}^3$ of $\text{H}_2\text{S}(\text{g})$ and $2y \text{ dm}^3$ of $\text{O}_2(\text{g})$ is injected into a closed container. The reaction proceeds to completion.

What is the total volume of gas, in dm^3 , present in the container after the reaction is completed?

A y

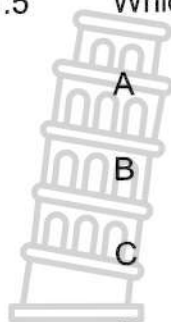
B $1,5y$

C $2y$

D $2,5y$

(2)

1.5 Which ONE of the following ions can act as an ampholyte?



A NO_3^-

B HPO_4^{2-}

C H_3O^+

D NH_4^+

(2)

1.6 X moles of sodium hydroxide is completely neutralised by a diprotic acid.
Which statement is correct at the equivalence point?
The number of moles of ...

A acid that reacts is X.

B acid that reacts is 2X.

C hydrogen ions that react is X.

D hydrogen ions that react is 2X.

(2)

[2 X 6 = 12]

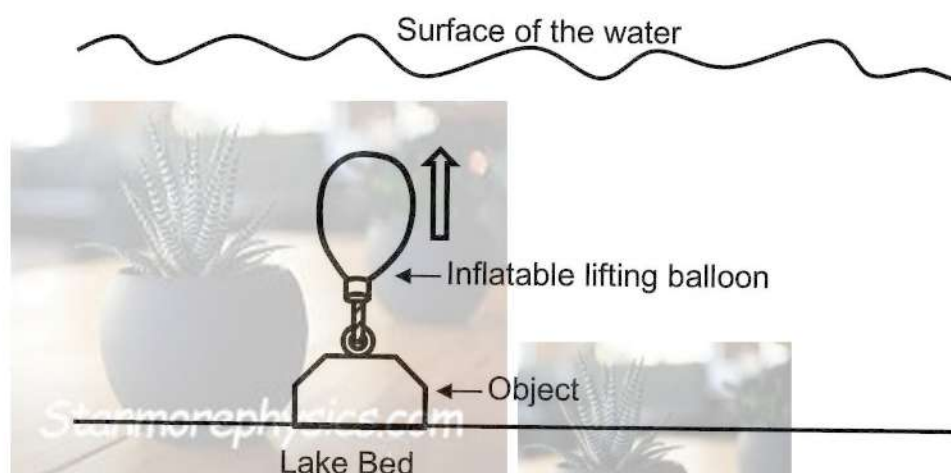
Stanmorephysics.com

QUESTION 2 (Start on a new page.)

An object resting on the bed of a lake is lifted by attaching it to an inflatable balloon.

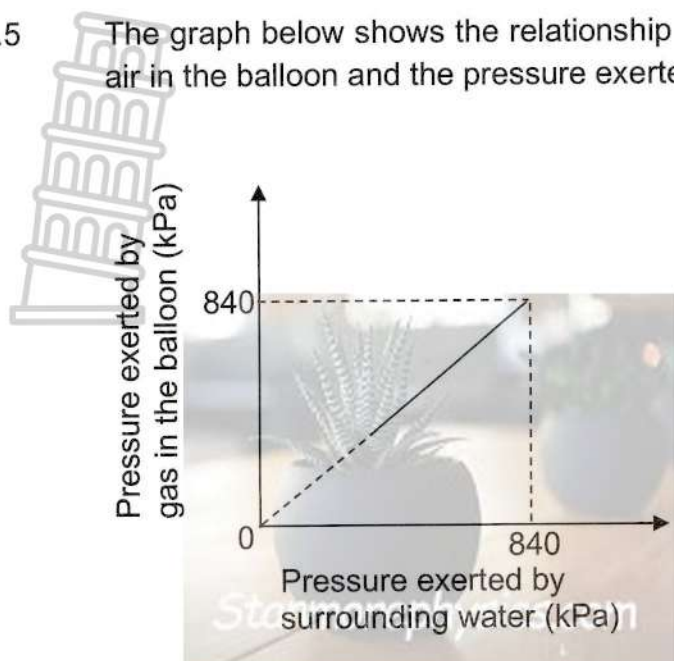
The balloon is filled with compressed atmospheric air and is then sealed so that no gas can enter or leave while it rises. As the balloon rises through the water, its volume increases. stanmorephysics.com

Assume that the temperature of the air in the balloon remains constant.



- 2.1 State *Boyle's law* in words. (2)
- 2.2 Explain why the volume of the balloon increases as it rises through the water. (2)
- 2.3 Explain why Boyle's law is likely to provide a more accurate prediction of the balloon's volume if it is filled with helium instead of atmospheric air. (3)
- 2.4 Draw a sketch graph of the volume occupied by the air in the balloon versus the pressure exerted by this air. (2)

- 2.5 The graph below shows the relationship between the pressure exerted by the air in the balloon and the pressure exerted by the surrounding water

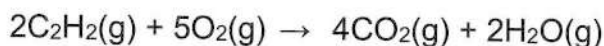


- 2.5.1 State ONE conclusion that can be drawn from this graph. (2)
- 2.5.2 At a pressure of 420 kPa, the balloon has a volume of 4 dm^3 . At point P, near the surface of the water, the pressure exerted by the water is 120 kPa. Calculate the volume of the balloon at point P. (4)
- 2.5.3 The balloon will burst if its volume reaches 16 dm^3 . The pressure exerted by the surrounding water at the surface of the lake is 100 kPa. Determine, with the aid of a calculation, whether the balloon will burst before reaching the surface of the lake. (4)

[19]

QUESTION 3 (Start on a new page.)

Acetylene gas, C_2H_2 , reacts with oxygen, O_2 , in an oxy-acetylene welding torch according to the balanced chemical equation below:



This reaction produces a very high-temperature flame capable of cutting and joining metals.

For this reaction:

- Energy of reactants = $260 \text{ kJ} \cdot \text{mol}^{-1}$
- Energy of products = $40 \text{ kJ} \cdot \text{mol}^{-1}$
- Activation energy = $180 \text{ kJ} \cdot \text{mol}^{-1}$

3.1 Define the term *heat of reaction*. (2)

3.2 Calculate ΔH , the heat of reaction. (2)

3.3 How does the sum of the bond energies of the reactants compare to the sum of the bond energies of the products? Choose from GREATER THAN, LESS THAN or EQUAL TO. (1)

3.4 Sketch the **potential energy versus course of reaction graph** to show the energy changes for this reaction. *Stanmorephysics.com*

On your graph, clearly indicate the following:

- Activated complex, labelled X, with its energy value
 - Energy of reactants (E_R) and energy of products (E_P)
 - Heat of reaction (ΔH)
 - Activation energy (E_a)
- (5)

3.5 Is this reaction EXOTHERMIC or ENDOTHERMIC? (1)

3.6 A spark is used to ignite the acetylene–oxygen mixture in a welding torch.

3.6.1 Explain why a spark is required to initiate combustion of the mixture. (1)

3.6.2 Explain why the reaction continues after ignition without further external energy. (2)

[14]

QUESTION 4 (Start on a new page.)

- 4.1 Sorbitol is a sweetener consisting of carbon (C), hydrogen (H) and oxygen(O) only.

A sample containing 0,25 mol of sorbitol is analysed. The molar mass of sorbitol is $182 \text{ g} \cdot \text{mol}^{-1}$. The sample contains 18 g of carbon and 3.5 g of hydrogen.

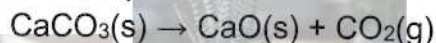
Determine:

- 4.1.1 The empirical formula of sorbitol. (5)

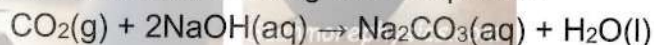
- 4.1.2 The molecular formula of sorbitol. (3)

- 4.2 A geologist is investigating a 25 g sample of impure limestone, which contains calcium carbonate, CaCO_3 , mixed with impurities such as sand and clay.

The sample is heated strongly. The impurities do not react, and all the CaCO_3 decomposes according to the equation:



All the carbon dioxide produced reacts completely with 200 cm^3 of a $2 \text{ mol} \cdot \text{dm}^{-3}$ NaOH solution, according to the equation:



- 4.2.1 Define the term *concentration*. (2)

- 4.2.2 Calculate the number of moles of NaOH that reacted. (3)

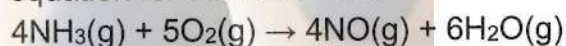
- 4.2.3 Determine the percentage purity of the calcium carbonate in the limestone sample. stanmorephysics.com (5)

[18]

QUESTION 5 (Start on a new page.)

During the Ostwald process, ammonia (NH_3) gas reacts with oxygen (O_2) in the presence of a catalyst to produce nitric oxide (NO) gas and water vapour (H_2O).

The balanced chemical equation for the reaction is:



A mixture containing $1,81 \times 10^{24}$ molecules of ammonia gas and 108,8 g of oxygen gas is allowed to react. The reaction is allowed to proceed to completion.

Take the molar gas volume to be $24,5 \text{ dm}^3 \cdot \text{mol}^{-1}$.

5.1 Define the term *limiting reagent*. (2)

5.2 Determine the limiting reagent in the above reaction. (5)

5.3 Calculate the volume of reactants remaining upon completion of the reaction. (4)

The volume of nitric oxide collected under these conditions is $56,6 \text{ dm}^3$.

5.4 Calculate the percentage yield of nitric oxide. (4)

[15]

QUESTION 6 (Start on a new page.)

6.1 Define a *Lowry-Brønsted acid*. (2)

6.2 H_2SO_4 is an acid widely used in industry and laboratories.

6.2.1 Write down the name for H_2SO_4 . (1)

6.2.2 Write a balanced chemical equation for the complete ionisation of H_2SO_4 in water. (3)

6.2.3 Write down the conjugate acid of SO_4^{2-} . (1)

6.3 A diprotic acid, H_2X , is dissolved in water to form a solution with a concentration of $0,1 \text{ mol}\cdot\text{dm}^{-3}$. The pH of this solution is 0,9.

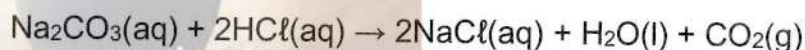
6.3.1 Explain what is meant by the term *diprotic acid*. (2)

6.3.2 Is H_2X a STRONG ACID or a WEAK ACID? Explain your answer using suitable calculations. (5)

6.4 A solution of sodium carbonate, Na_2CO_3 , was prepared by dissolving an unknown mass of pure $\text{Na}_2\text{CO}_3(\text{s})$ in water and making the solution up to a volume of 250 cm^3 . stanmorephysics.com

In a titration with hydrochloric acid (HCl), 25 cm^3 of this Na_2CO_3 solution required 20 cm^3 of HCl of concentration $0,6 \text{ mol}\cdot\text{dm}^{-3}$ for complete neutralisation.

The balanced chemical equation for the reaction is:



6.4.1 Calculate the mass of Na_2CO_3 used to prepare the original 250 cm^3 solution. (5)

6.4.2 A 50 cm^3 sample of the $0,6 \text{ mol}\cdot\text{dm}^{-3}$ hydrochloric acid solution was diluted by adding distilled water and making up to a volume of 250 cm^3 .

Calculate the concentration of this diluted hydrochloric acid solution. (3)
[22]

TOTAL: 100

DATA FOR PHYSICAL SCIENCES GRADE 11

CHEMISTRY

TABLE 1: PHYSICAL CONSTANTS

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

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$\text{pH} = -\log[\text{H}_3\text{O}^+]$
$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14} \text{ at } 298 \text{ K}$	
$P_1 V_1 = P_2 V_2 \text{ (T constant)}$	

TABLE 3: THE PERIODIC TABLE OF ELEMENTS



KEY/SLEUTEL																	
Atomic number Atoomgetal																	
29 Cu 63,5																	
Electronegativity Elektronegatiwiteit																	
Approximate relative atomic mass Benaderde relatieve atoommassa																	
Symbol Simbool																	
1 H 1,008																	
2 He 4,003																	
3 Li 6,941																	
4 Be 9,012																	
5 B 10,811																	
6 C 12,011																	
7 N 14,007																	
8 O 15,999																	
9 F 18,998																	
10 Ne 20,180																	
11 Na 22,990																	
12 Mg 24,305																	
13 Al 26,982																	
14 Si 28,086																	
15 P 30,974																	
16 S 32,065																	
17 Cl 35,453																	
18 Ar 39,948																	
19 K 39,098																	
20 Ca 40,078																	
21 Sc 44,956																	
22 Ti 47,883																	
23 V 50,942																	
24 Cr 51,996																	
25 Mn 54,938																	
26 Fe 55,845																	
27 Co 58,933																	
28 Ni 58,693																	
29 Cu 63,546																	
30 Zn 65,380																	
31 Ga 69,723																	
32 Ge 72,630																	
33 As 74,922																	
34 Se 78,960																	
35 Br 79,904																	
36 Kr 83,798																	
37 Rb 85,468																	
38 Sr 87,62																	
39 Y 88,906																	
40 Zr 91,224																	
41 Nb 92,906																	
42 Mo 95,94																	
43 Tc 98,906																	
44 Ru 101,07																	
45 Rh 102,905																	
46 Pd 106,42																	
47 Ag 107,868																	
48 Cd 112,411																	
49 In 114,818																	
50 Sn 118,710																	
51 Sb 121,757																	
52 Te 127,6																	
53 I 126,905																	
54 Xe 131,29																	
55 Cs 132,905																	
56 Ba 137,327																	
57 La 138,905																	
58 Ce 140,127																	
59 Pr 140,908																	
60 Nd 144,242																	
61 Pm 144,913																	
62 Sm 150,36																	
63 Eu 151,964																	
64 Gd 157,25																	
65 Tb 158,925																	
66 Dy 162,50																	
67 Ho 164,930																	
68 Er 167,26																	
69 Tm 168,933																	
70 Yb 173,054																	
71 Lu 174,967																	
72 Hf 178,49																	
73 Ta 180,948																	
74 W 183,84																	
75 Re 186,207																	
76 Os 190,23																	
77 Ir 192,222																	
78 Pt 195,084																	
79 Au 196,967																	
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 227																	
90 Th 232																	
91 Pa 231																	
92 U 238																	
93 Np 237																	
94 Pu 244																	
95 Am 243																	
96 Cm 247																	
97 Bk 247																	
98 Cf 251																	
99 Es 252																	
100 Fm 257																	
101 Md 258																	
102 No 259																	
103 Lr 262																	



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**PROVINCIAL STANDARDISED
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GRADE 11

**PHYSICAL SCIENCES
MARKING GUIDELINES
SEPTEMBER 2026**

MARKS: 100

DURATION: 2 hours

This marking guidelines consists of 8 pages.

QUESTION 1:

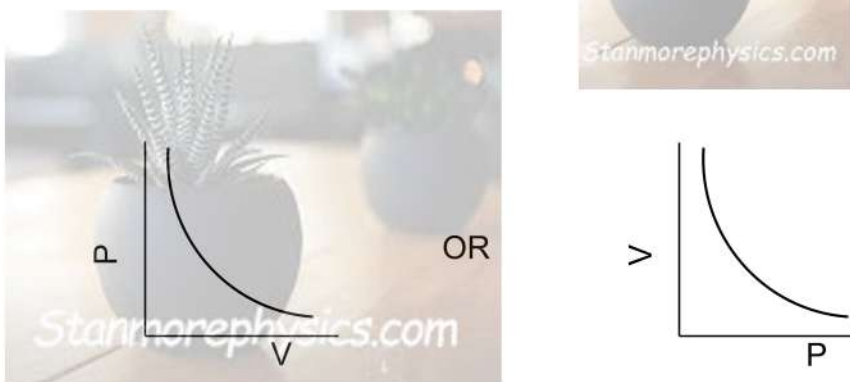
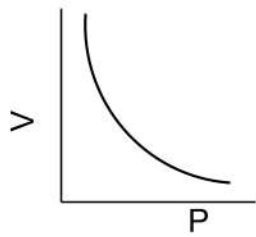
- | | | |
|-----|------|-------------|
| 1.1 | B ✓✓ | (2) |
| 1.2 | A ✓✓ | (2) |
| 1.3 | C ✓✓ | (2) |
| 1.4 | B ✓✓ | (2) |
| 1.5 | B ✓✓ | (2) |
| 1.6 | C ✓✓ | (2) |
| | | [12] |

QUESTION 2

- 2.1 The pressure of an enclosed gas is inversely proportional to the volume it occupies ✓ at a constant temperature. ✓ (2)

- 2.2 As the balloon rises, the pressure exerted by the water decreases. ✓
Therefore the pressure exerted by the gas decreases ✓ (2)

- 2.3 Helium atoms are smaller and occupy a negligible volume ✓ compared with the particles in air.
At higher pressures, further increases in pressure will decrease the volume more for helium gas than for atmospheric gas ✓
Therefore helium behaves more like an ideal gas ✓ compared to the gases in air (so its pressure-volume relationship more closely follows Boyle's law) (3)

- 2.4  OR  ✓✓ (2)

- 2.5.1 The pressure exerted by the gas in the balloon is equal to the pressure exerted by surrounding water/ The pressure exerted by the gas in the balloon is directly proportional to the pressure exerted by surrounding water/ The gradient of the graph is 1. ✓✓stanmorephysics.com (2)

- 2.5.2 $p_1V_1 = p_2V_2$ ✓
 $420 \times 4 = 120 \times V_2$ ✓
 $V_2 = 14 \text{ dm}^3$ ✓ (4)

2.5.3

OPTION 1 The balloon will burst. ✓ $p_1V_1 = p_2V_2$ $420 \times 4 \checkmark = p_2 \times 16 \checkmark$ $p_2 = 105 \text{ kPa}$ $p_2 \text{ (or } 105 \text{ kPa)} > 100 \text{ kPa} \checkmark$	OPTION 2 The balloon will burst. ✓ $p_1V_1 = p_2V_2$ $420 \times 4 \checkmark = 100 \times V_2 \checkmark$ $V_2 = 16,8 \text{ dm}^3$ $V_2 (16,8) > 16 \text{ dm}^3 \checkmark$
OPTION 3 (POSITIVE MARKING FROM 2.5.1) The balloon will burst. ✓ $p_1V_1 = p_2V_2$ $120 \times 14 \checkmark = p_2 \times 16 \checkmark$ $p_2 = 105 \text{ kPa}$ $p_2 \text{ (or } 105 \text{ kPa)} > 100 \text{ kPa} \checkmark$	OPTION 4 (POSITIVE MARKING FROM 2.5.1) The balloon will burst. ✓ $p_1V_1 = p_2V_2$ $120 \times 14 \checkmark = 100 \times V_2 \checkmark$ $V_2 = 16,8 \text{ dm}^3$ $V_2 (16,8) > 16 \text{ dm}^3 \checkmark$

(4)

[19]

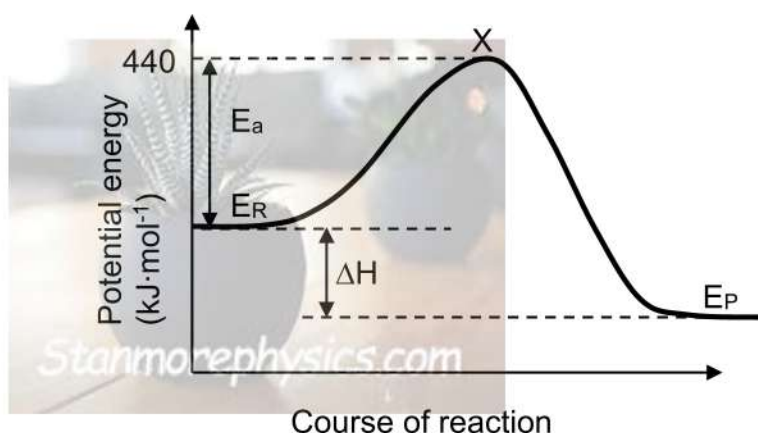
QUESTION 3

3.1 The energy absorbed or released per mole ✓✓ (in a chemical reaction) (2 or 0) (2)

3.2 $\Delta H = E_P - E_R$
 $= 40 - 260 \checkmark$
 $= -220 \text{ kJ} \cdot \text{mol}^{-1} \checkmark$ (2)

3.3 Less than ✓ (1)

3.4



NOTE: If the graph of an endothermic reaction is drawn, award a maximum of 3 marks (bullets 3, 4 and 5 if correctly indicated). stanmorephysics.com

Marking criteria:

- Shape of curve (must be for exothermic reaction) ✓
- E_R , E_P and ΔH correctly labelled ✓
- E_a correctly labelled ✓
- Activated complex correctly labelled as X on the peak ✓
- Energy of activated complex = $440 \text{ kJ} \cdot \text{mol}^{-1}$ ✓

(5)

3.5 Exothermic ✓

(1)

3.6.1 A spark/heat energy is required to provide the activation energy ✓ needed to initiate the reaction.

(1)

3.6.2 The combustion reaction is exothermic / energy is released ✓ when products are formed.

Part of the energy released provides the activation energy for more particles to react ✓ **OR** The heat produced by the reaction continues the reaction.

(2)

[14]**QUESTION 4**

4.1.1

Marking criteria:

- Substitute into formula to find mass of sorbitol ✓
- Subtract mass of C and H from mass of sorbitol to obtain mass of O ✓
- Calculate the number of moles of all 3 elements ✓
- Determine the simplest ratio of all elements ✓
- Final answer: $\text{C}_3\text{H}_7\text{O}_3$ ✓

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

$$0,25 = \frac{m}{182} \quad \checkmark$$

$$m(\text{sorbitol}) = 45,5 \text{ g}$$

$$m(\text{O}) = 45,5 - (18 + 3,5) \quad \checkmark$$

$$= 24 \text{ g}$$

Element	mass (g)	$n = \frac{m}{M}$	Simplest Ratio		
C	18	$\frac{18}{12} = 1,5$	1,5	$\times 2$ OR $\times \frac{3}{1,5}$ $\checkmark$	3
H	3,5	$\frac{3,5}{1} = 3,5$ ✓	3,5		7
O	24	$\frac{24}{16} = 1,5$	1,5		3

Empirical Formula: $\text{C}_3\text{H}_7\text{O}_3$ ✓

(5)

4.1.2 $M(C_3H_7O_3) = 3 \times 12 + 1 \times 7 + 3 \times 16 \checkmark$
 $= 91 \text{ g} \cdot \text{mol}^{-1}$

$\frac{182}{91} \checkmark = 2$

Molecular formula : $C_6H_{14}O_6 \checkmark$

(3)

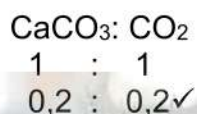
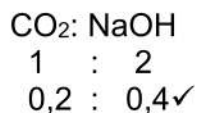
4.2.1 The amount of solute/ dissolved substance/ mole per litre/dm³ of solution. $\checkmark \checkmark$
(2 OR 0)

(2)

4.2.2 $c = \frac{n}{V} \checkmark$
 $2 = \frac{n}{0,2} \checkmark$
 $n = 0,4 \text{ mol} \checkmark$

(3)

4.2.3 **POSITIVE MARKING FROM QUESTION 4.2.2**



$m(CaCO_3) = nM$
 $= 0,2 \times 100 \checkmark$
 $= 20 \text{ g}$

$\% \text{ purity} = \frac{\text{pure mass}}{\text{total sample mass}} \times 100$
 $= \frac{20}{25} \times 100 \checkmark$
 $= 80 \% \checkmark$

NOTE:

Ratios may be shown in a table. Mark accordingly

(5)

[18]

QUESTION 5

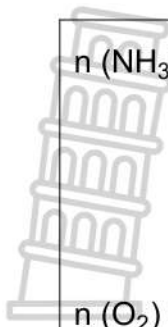
5.1 The reactant that is completely consumed in a chemical reaction OR The reactant that is used up first in a chemical reaction OR The reactant that limits/determine the amount of product formed. $\checkmark \checkmark$ **(2 OR 0)**

(2)

NOTE:

For Questions 5.2, 5.3 and 5.4, calculations may be done in a single table. Award marks if the calculations (ratios for Q5.2 and Q5.4, and the subtraction for Q5.3) are correct in the table. stanmorephysics.com

5.2



$$n(\text{NH}_3) = \frac{N}{N_A} \checkmark$$

$$= \frac{1,81 \times 10^{24}}{6,02 \times 10^{23}} \checkmark$$

$$= 3,01 \text{ mol}$$

$$n(\text{O}_2) = \frac{m}{M}$$

$$= \frac{108,8}{32} \checkmark$$

$$= 3,4 \text{ mol}$$

OPTION 1 NH ₃ : O ₂ 4 : 5 3,01 : 3,76 ✓	OPTION 2 NH ₃ : O ₂ 4 : 5 2,72 : 3,4 ✓	OPTION 3 $\frac{3,01}{4} > \frac{3,4}{5} \checkmark$
O ₂ / Oxygen is the limiting reagent ✓		

(5)

5.3

POSTIVE MARKING FROM QUESTION 5.2

$$n(\text{NH}_3)_{\text{excess}} = 3,01 - 2,72 \checkmark$$

$$= 0,29 \text{ mol}$$

$$n = \frac{V}{V_{m}} \checkmark$$

$$0,29 = \frac{V}{24,5} \checkmark$$

$$V(\text{NH}_3)_{\text{excess}} = 7,11 \text{ dm}^3 (7,105 \text{ dm}^3) \checkmark$$



(4)

5.4

POSTIVE MARKING FROM QUESTION 5.2

$$\text{O}_2 : \text{NO}$$

$$5 : 4$$

$$3,4 : 2,72 \checkmark$$

OR

$$\text{NH}_3 : \text{NO}$$

$$4 : 4 \text{ (OR 1:1)}$$

$$2,72 : 2,72 \checkmark$$

OPTION 1

$$n = \frac{V}{V_{m}}$$

$$2,72 = \frac{V}{24,5} \checkmark$$

$$V = 66,64 \text{ dm}^3$$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{56,6}{66,64} \times 100 \checkmark$$

$$= 84,93 \% \checkmark$$

OPTION 2

$$n = \frac{V}{V_{m}}$$

$$= \frac{56,6}{24,5} \checkmark$$

$$= 2,31 \text{ mol}$$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{2,31}{2,72} \times 100 \checkmark$$

$$= 84,93 \% \checkmark$$

(4)

[15]

QUESTION 6

6.1 An acid is a proton/ H^+ donor ✓✓ (2 OR 0) (2)

6.2.1 Hydrogen sulphate / Sulphuric acid ✓ (1)

6.2.2 $H_2SO_4 + 2H_2O \checkmark \rightarrow 2H_3O^+ + SO_4^{2-} \checkmark$ Balancing ✓ (3)

6.2.3 $HSO_4^- \checkmark$ (1)

6.3.1 A diprotic acid is an acid that can donate two hydrogen ions/ H^+ /protons per molecule in aqueous solution. ✓✓ (2)

6.3.2

$H_2X + H_2O \rightarrow H_3O^+ + HX^-$
 If complete ionization took place:
 $[H_3O^+] = [H_2X]$
 $= (0,1) \text{ mol} \cdot \text{dm}^{-3} \checkmark$

$pH = -\log[H_3O^+] \checkmark$
 $0,9 = -\log[H_3O^+] \checkmark$
 $[H_3O^+] = 0,13 \text{ mol} \cdot \text{dm}^{-3}$

- H_2X ionized completely in water ✓.
- Therefore, H_2X is a strong acid ✓

ACCEPT:
[Assume H_2X ionises completely to produce $2H_3O^+$]
 $H_2X + 2H_2O \rightarrow 2H_3O^+ + X^{2-}$
 If complete ionization took place:
 $[H_3O^+] = 2 [H_2X]$
 $= 2(0,1) \checkmark$
 $= 0,2 \text{ mol} \cdot \text{dm}^{-3}$

$pH = -\log[H_3O^+] \checkmark$
 $0,9 = -\log[H_3O^+] \checkmark$
 $[H_3O^+] = 0,13 \text{ mol} \cdot \text{dm}^{-3}$

- H_2X ionized partially/ incompletely in water ✓.
- Therefore, H_2X is a weak acid ✓

$pH = -\log[H_3O^+] \checkmark$
 $= -\log[0,2] \checkmark$
 $= 0,7$

- H_2X ionized partially/ incompletely in water ✓.
- Therefore, H_2X is a weak acid ✓

NB: Credit for Strong Acid or Weak Acid will only be given when a suitable calculation is performed. (5)

6.4.1

OPTION 1

$$\begin{aligned} n(\text{HCl}) &= cV \\ &= 0,6 \times 0,02 \checkmark \\ &= 0,012 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Na}_2\text{CO}_3) &= \frac{1}{2} n(\text{HCl}) \\ &= 0,5(0,012) \checkmark \\ &= 0,006 \text{ mol in } 25 \text{ cm}^3 \end{aligned}$$

$$\begin{aligned} n(\text{Na}_2\text{CO}_3) \text{ in } 250 \text{ cm}^3 &= \frac{250}{25} \times 0,006 \checkmark \\ &= 0,06 \text{ mol} \end{aligned}$$

$$\begin{aligned} m(\text{Na}_2\text{CO}_3) &= nM \\ &= 0,06 \times 106 \checkmark \\ &= 6,36 \text{ g} \checkmark \end{aligned}$$

OPTION 2

$$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$$

$$\frac{0,6 \times 20 \checkmark}{c_b \times 25 \checkmark} = \frac{2}{1} \checkmark$$

$$c(\text{Na}_2\text{CO}_3) = 0,24 \text{ mol} \cdot \text{dm}^{-3}$$

$$c(\text{Na}_2\text{CO}_3) = \frac{m}{MV}$$

$$0,24 = \frac{m}{106 \times 0,25} \checkmark$$

$$m = 6,36 \text{ g} \checkmark$$

OPTION 3

$$\begin{aligned} n(\text{HCl}) &= cV \\ &= 0,6 \times 0,02 \checkmark \\ &= 0,012 \text{ mol} \end{aligned}$$

$$\begin{aligned} n(\text{Na}_2\text{CO}_3) &= \frac{1}{2} n(\text{HCl}) \\ &= 0,5(0,012) \checkmark \\ &= 0,006 \text{ mol} \end{aligned}$$

$$\begin{aligned} c(\text{Na}_2\text{CO}_3) &= \frac{n}{V} \\ &= \frac{0,006}{0,025} \checkmark \\ &= 0,24 \text{ mol} \cdot \text{dm}^{-3} \end{aligned}$$

$$c(\text{Na}_2\text{CO}_3) = \frac{m}{MV}$$

$$0,24 = \frac{m}{106 \times 0,25} \checkmark$$

$$m = 6,36 \text{ g} \checkmark$$

(5)

6.4.2

$$\begin{aligned} C_1 V_1 &= C_2 V_2 \\ 0,6 \times 50 \checkmark &= C_2 \times 250 \checkmark \\ C_2 &= 0,12 \text{ mol} \cdot \text{dm}^{-3} \checkmark \end{aligned}$$

(3)

[22]**TOTAL:****100**