KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 11

PHYSICAL SCIENCES

COMMON TEST

SEPTEMBER 2024

TIME: 2 hours

MARKS: 100

This question paper consists of 8 pages and two data sheets.

 Please turn over

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

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 — 1.5) in the ANSWER BOOK, for example 1.6 D.

1.1 The number of hydrogen atoms in one mole of ammonia (NH_3) is…

A 3
B $1,204 \times 10^{24}$
C $1,806 \times 10^{24}$
D $6,02 \times 10^{23}$

(2)

1.2 Which ONE of the following gases occupies the largest volume at STP?

A 32 g of $O_2(g)$
B 34 g of $NH_3(g)$
C 7 g of $N_2(g)$
D 4 g of He(g) (2)

1.3 Real gas behaviour deviates from ideal gas behaviour at…

A Low temperatures and low pressures
B Moderate temperatures and high pressures
C Moderate temperatures and low pressures
D Low temperatures and high pressures (2)

1.4 In a chemical reaction, the difference between the potential energy of the products and the potential energy of reactants is equal to:

A Enthalpy of the reaction
B Rate of the reaction
C Enthalpy change of the reaction
D Total potential energy of the particles (2)

1.5 Which ONE of the following is the correct description of a solution of hydrochloric acid of concentration 0,1 $mol \cdot dm^{-3}$?

A Dilute strong acid
B Dilute weak acid
C Concentrated strong acid
D Concentrated weak acid (2)

[10]

QUESTION 2

2.1 Define the term *molar mass*. (2)

2.2 Calculate the percentage of carbon in cane sugar $C_{12}H_{22}O_{11}$. (2)

2.3 C_xH_y is a compound made up of carbon (C) and hydrogen (H) only.
1,97g of this compound reacts with excess O_2 (g) to produce 6,2g of CO_2 (g).
Determine the empirical formula of this compound. (6)

2.4 A metal M forms two chlorides, $MC\ell_2$ and $MC\ell_x$, that contain 55,9% and 65,5% chlorine by mass respectively. Determine the:

2.4.1 Relative atomic mass of M (4)

2.4.2 Value of x. Show all working. (4)
[18]

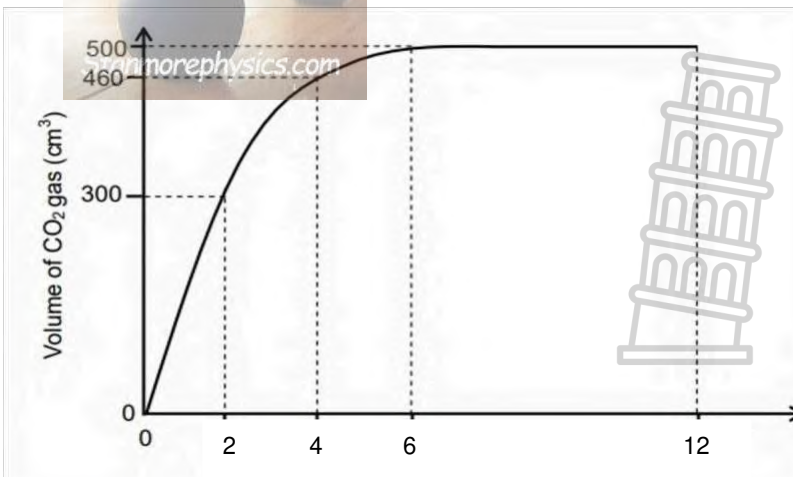
QUESTION 3

In an experiment, a 300 cm^3 solution of hydrochloric acid ($HC\ell$) of concentration 0,5 $mol.dm^{-3}$ reacts with calcium carbonate powder. The $HC\ell$ is in excess.

The following balanced reaction takes place at 25^0C.

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

The volume of carbon dioxide gas produced is measured at regular time intervals and the following graph is drawn:



3.1 Define the term *concentration*. (2)

3.2 Give a reason why the graph is horizontal after 6 minutes. (1)

3.3 Determine the maximum number of moles of carbon dioxide gas (CO_2) produced. Take the molar gas volume at 25°C to be 24000cm^3. (3)

3.4 Calculate the concentration of the HCℓ solution after 6 minutes. Assume that the volume of the solution remains at 300 cm^3. (7)

[13]

QUESTION 4

4.1 A laboratory assistant prepares a solution of calcium nitrate of volume 250cm^3 using $Ca(NO_3)_2 \cdot 4H_2O$ (s) as the solute:

$$Ca(NO_3)_2 \rightarrow Ca^{2+}(aq) + 2NO_3^-(aq)$$

If the concentration of the nitrate ions in the solution is 0,15 mol·dm^{-3}, calculate the mass of solute that the laboratory assistant used. (5)

4.2 The chemical reaction for the production of aspirin($C_9H_8O_4$), from salicylic acid ($C_7H_6O_3$) and acetoacetic acid($C_4H_6O_3$), is represented by the balanced equation below.

$$2C_7H_6O_3 + C_4H_6O_3 \rightarrow 2C_9H_8O_4 + H_2O$$

aspirin

A chemist reacts 14 g salicylic acid with 10 g of acetoacetic acid.

4.2.1 Define *limiting reagent*. (2)

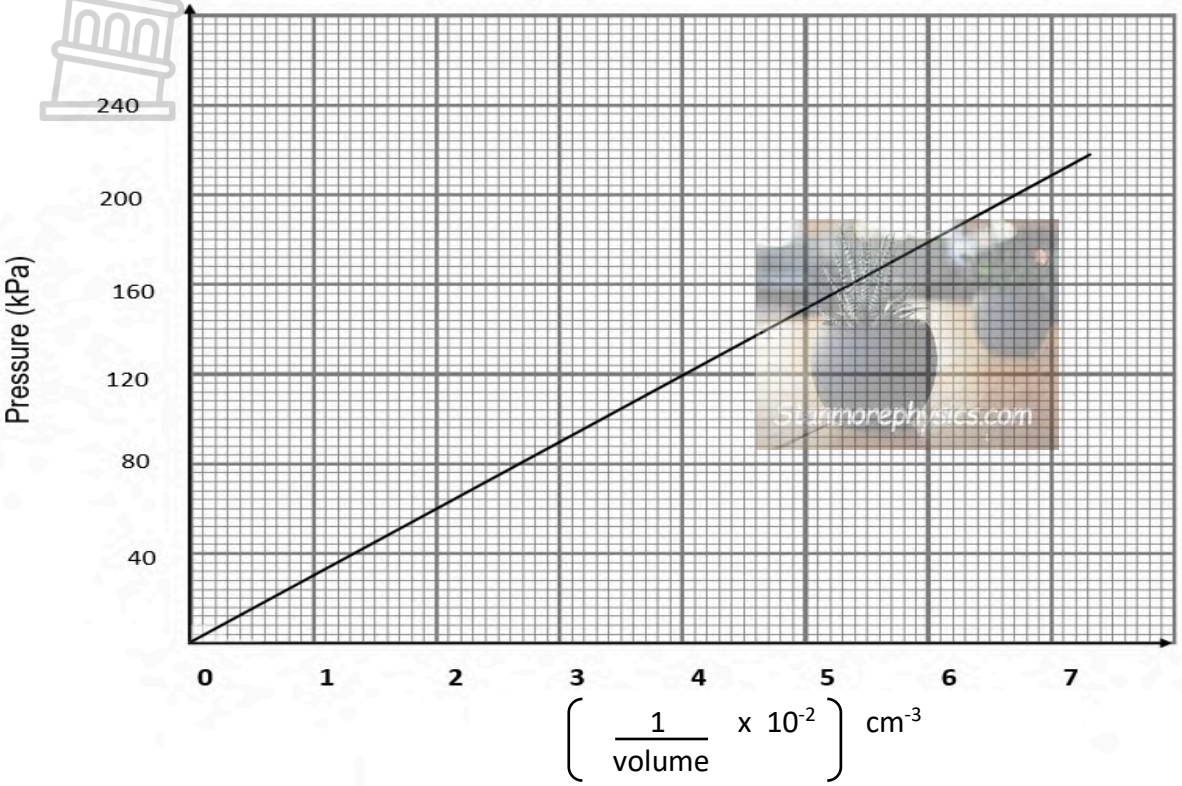
4.2.2 By means of a suitable calculation, determine which of the reactants is the limiting reagent. (4)

4.2.3 The actual mass of aspirin obtained at the end of the reaction is 11,5 g. Calculate the percentage yield of this reaction. (5)

[16]

QUESTION 5

A group of learners perform an experiment to verify a gas law. The results of the experiment are shown in the graph of pressure vs the inverse of volume drawn below.



5.1 NAME the law being verified. (1)

5.2 Write down an investigative question for this experiment. (2)

5.3 Name TWO variables that must be kept constant during the experiment. (2)

5.4 Calculate the volume occupied by the gas when the pressure exerted by the gas is 200kPa. (3)

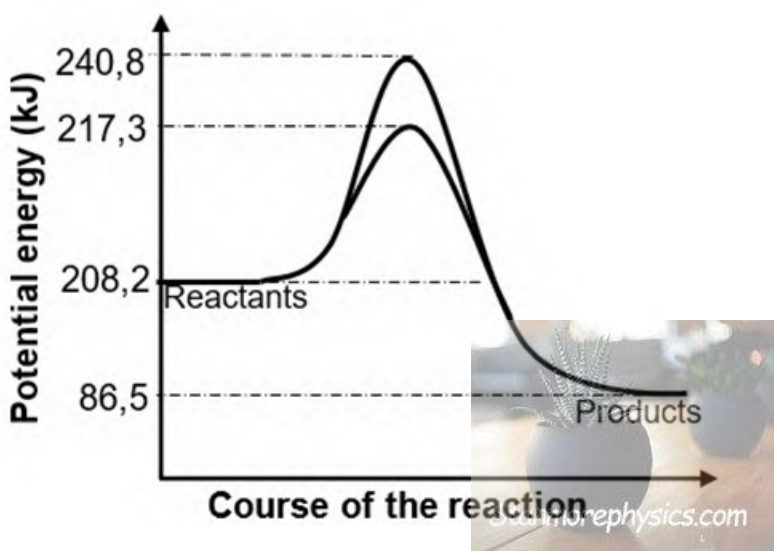
5.5 Determine the pressure exerted by the gas when its volume is 11,11cm^3 (3)

5.6 State 2 properties of an Ideal Gas (2)

[13]

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 *activation energy*. (2)

6.3 Write down the values for the:

6.3.1 Energy of the reactants (1)
6.3.2 Energy of the products (1)
6.3.3 Activation energy for the reverse reaction (1)
6.3.4 Activation energy for the catalysed forward reaction (1)
6.3.5 Energy of the activated complex in the absence of a catalyst (1)

6.4 Calculate the heat of reaction, (ΔH), for the reverse reaction. (2)

6.5 What effect will the addition of the catalyst have on:
(Choose from INCREASES, DECREASES or REMAINS THE SAME)
6.5.1 The energy of the products? (1)
6.5.2 The heat of reaction? (1)
6.5.3 The activation energy for the reverse reaction? (1)

[14]

QUESTION 7

7.1 Given the following acid-base reaction:

$$NH_3 + H_3PO_4 \rightleftharpoons NH_4^+ + H_2PO_4^-$$

7.1.1 Define a base according to the *Lowry-Bronsted* theory. (1)

7.1.2 Identify the TWO bases in the above reaction. (2)

7.1.3 Define the term *ampholyte*. (2)

7.1.4 Write down the FORMULA of an ampholyte in the above reaction. (1)

7.2 A learner reacts 20 cm^3 of a 0,2 $mol \cdot dm^{-3}$ solution of sodium carbonate, completely with 12 cm^3 of hydrochloric acid solution. The balanced equation for this reaction is:

$$Na_2CO_3 + 2HC\ell \rightarrow 2NaC\ell + CO_2 + H_2O$$

Calculate the:

7.2.1 Number of moles of Na_2CO_3 that reacted. (3)

7.2.2 Concentration of the hydrochloric acid solution. (4)

7.2.3 pH of the hydrochloric acid solution before it reacted. (3)

[16]

TOTAL : 100

DATA FOR PHYSICAL SCIENCES GRADE 11

PAPER 2 (CHEMISTRY)

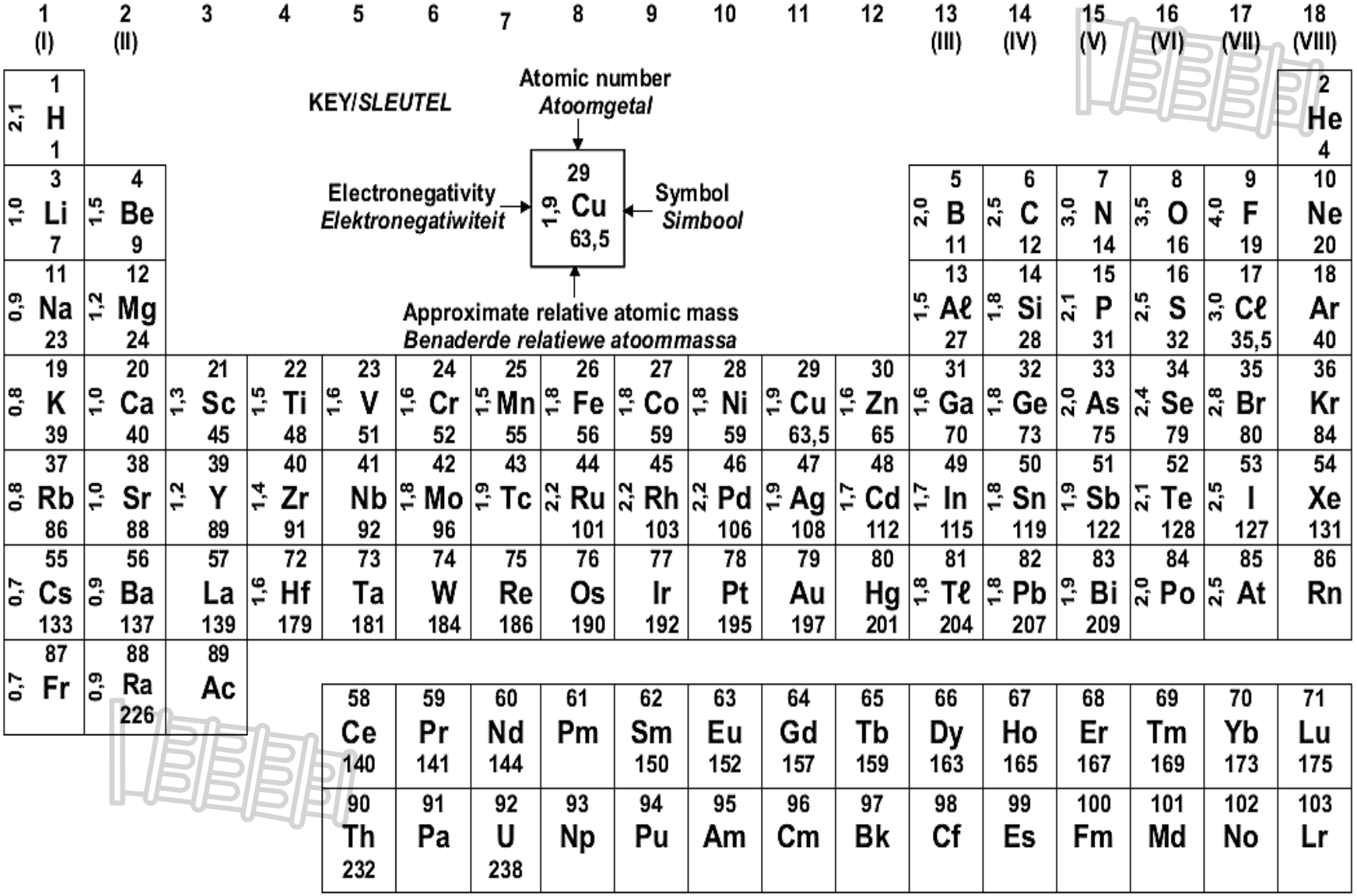
TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

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

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$ $n = \frac{N}{N_A}$ $n = \frac{V}{V_m}$	$c = \frac{n}{V}$ $\quad c = \frac{m}{MV}$ $\frac{c_A V_A}{c_B V_B} = \frac{n_A}{n_B}$	$p_1V_1 = p_2V_2$

TABLE 3: THE PERIODIC TABLE OF ELEMENTS/*TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE*



Education

KwaZulu-Natal Department of Education
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MARKING GUIDELINES

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NB: This marking guideline consists of 6 pages.

QUESTION ONE

1.1 C ✓✓
1.2 B ✓✓
1.3 D ✓✓
1.4 C ✓✓
1.5 A ✓✓ **[10]**

QUESTION TWO

2.1 The mass of one mole of a substance. ✓✓ (2)

2.2 $M\ (C_{12}H_{22}O_{11}) = 12(12) + 22(1) + 11(16)$
$= 144 + 22 + 176$
$= 342\ g.mol^{-1}$ ✓

$\%\ C = \frac{144}{342} \times 100 = 42,11\%$ ✓

(2)

2.3 Mass of C in 6,2g of CO_2:
$\frac{12}{44} \times 6,2 = 1,69g$✓
∴ mass of C in C_xH_y is 1,69 g✓

Mass of H in C_xH_y = 1,97 – 1,69✓
= 0,28g

	C	H
Mass	1,69 g	0,28 g
n = m/M	$\frac{1,69}{12}$✓	$\frac{0,28}{1}$✓
	= 0,14	= 0,28
Divide by smallest	$\frac{0,14}{0,14}$	$\frac{0,28}{0,14}$
Ratio	1	2
Empirical formula is CH_2✓		

(6)

2.4.1 $\frac{M}{M+71}$✓✓ $\times 100 = 44,1$✓ OR $\frac{71}{M+71}$✓✓ $\times 100 = 55,9$✓

$M = 56\ g \cdot mol^{-1}$✓

(4)

2.4.2 $\frac{x(35,5)}{56+x(35,5)}$✓✓ $= \frac{65,5}{100}$✓

$x = 3$✓ (4)

[18]

QUESTION 3

3.1 The amount of solute per dm^3 of solution. / The number of moles of a substance per unit volume. ✓✓ (2)

3.2 No more carbon dioxide is produced. ✓/ The reaction has ended / All the $CaCO_3$ has reacted. (1)

3.3 $n = \frac{V}{V_m}$ ✓

$= \frac{500}{24000}$ ✓

$= 0,0208$ mol ✓ (3)

3.4 **POSITIVE MARKING FROM 3.3**

MARKING CRITERIA:

- Substitution / answer: calculation of initial moles of HCl. ✓
- Apply ratio of moles of HCl to CO_2.(2:1). ✓
- Subtracting moles that reacted from initial moles of HCl. ✓✓
- Formula to calculate concentration. ✓
- Substitution into concentration formula. ✓
- Final answer. ✓

OPTION 1

(7)

$n_i = cV = 0,5 \times 0,3$✓

$= 0,15$ mol

$n_{reacted} = 2 \times 0,0208$✓

$= 0,0416$ mol

$n_{excess} = n_i - n_{reacted}$

$= 0,15 - 0,0416$✓✓

$= 0,1084$ mol

$c = \frac{n}{V}$✓

$= \frac{0,1084}{0,3}$✓

$= 0,361$ mol.dm^{-3}✓

OPTION 2

	$CaCO_3$	$2HCl$		$CaCl_2$	H_2O	CO_2
Ratio	1	2		1	1	1
Initial		0,15	✓			0
Change		-0,0416	✓			0,0208
End		0,1084	✓✓			

[13]

QUESTION 4

4.1. $n(NO_3^-)$ = C x V
= 0,15 x 0,25 ✓
= 0,0375 mol
$n(Ca(NO_3^-))$ = ½(0,0375) ✓
= 0,01875 mol

∴ mass of $Ca(NO_3)_2 \cdot 4H_2O$ used
m = nM ✓
= 0,01875(164 +4(18)) ✓
= 4,425 g✓ (5)

4.2.1 The reactant that is used up first/completely in a chemical reaction. ✓✓ (2)
OR the reactant that determines the amount of product that is formed

4.2.2 $n(C_7H_6O_3) = \frac{m}{M}$
$= \frac{14}{138}$ ✓
= 0,10 mol

$n(C_4H_6O_3) = \frac{m}{M}$
$= \frac{10}{102}$ ✓
= 0,10 mol

From balanced equation:
$n(C_7H_6O_3) : n(C_4H_6O_3)$
2 : 1

∴ 0,1 mol of $C_7H_6O_3$ needs 0,05 mol of $C_4H_6O_3$ ✓

∴ The limiting reactant is $C_7H_6O_3$ ✓ (4)

4.2.3 $n(C_9H_8O_4) = \frac{m}{M}$

0,1✓ = $\frac{m}{180}$✓

∴m = 18 g (18,26 g) ✓

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

$= \frac{11,5}{18} \times 100$ ✓

= 63,90% (62,98%)✓ (5)
[16]

QUESTION 5

5.1 Boyle's Law ✓ (1)

5.2 What is the <u>relationship between the pressure exerted and the volume occupied by</u> a fixed mass of (dry) gas at constant temperature? ✓✓ (2)

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

5.4 At 200kPa $1/v = 6,7 \times 10^{-2}$ ✓

$$\therefore v = \frac{1}{6,7 \times 10^{-2}} \quad ✓$$

$v = 14,93\ cm^{-3}$ ✓ (3)

5.5 $p_1v_1 = p_2v_2$✓

$120(25) = p_2\ (11,11)$ ✓ (or any other correct combinations for p_1 and v_1 from the graph)

$p_2 = 270,03$ kPa✓ (3)

5.6 The particles of the ideal gas: (any 2)

- Occupy no volume.
- Are identical in all ways.
- Exert no forces on each other except during a collision.
- All collisions between gas molecules are completely elastic. (2)

[13]

QUESTION 6

6.1 Exothermic.✓
$\Delta H < 0$ ✓ / $E_{products} < E_{reactants}$ (2)

6.2 The minimum energy needed for a reaction to take place✓✓ (2)

6.3.1 208,2 kJ✓ (1)

6.3.2 86,5 kJ✓ (1)

6.3.3 154,3 kJ OR 130,8 kJ✓ (1)

6.3.4 9,1 kJ✓ (1)

6.3.5 240,8 kJ✓ (1)

6.4 $\Delta H = E_{products} - E_{reactants}$

$= 208,2 - 86,5$ ✓ $= 121,7$ kJ✓ (2)

6.5.1 Remains the same .✓ (1)

6.5.2 Remains the same.✓ (1)

6.5.3 Decreases.✓ (1)

[14]

QUESTION 7

7.1.1 A base is a proton acceptor. ✓ (1)

7.1.2 NH_3 ✓ and $H_2PO_4^-$ ✓ (2)

7.1.3 A substance that acts as an acid and base. ✓✓ (2)

7.1.4 $H_2PO_4^-$ ✓ (1)

7.2.1 n (Na_2CO_3) = c x V ✓
= 0,2 x 0,02 ✓
= 0,004 mol ✓ (3)

7.2.2 **POSITIVE MARKING FROM QUESTION 7.2.1**

OPTION 1:

n (Na_2CO_3) : n (HCl)
1 : 2

∴ n (HCl) = 2 x 0,04✓ = 0,008 mol

$c = \frac{n}{v}$

$= \frac{0,008}{0,012}$ ✓ ✓

= 0,67 mol.dm^{-3} ✓

OPTION 2:

$\frac{c_A V_A}{c_B V_B} = \frac{n_A}{n_B}$

$\frac{c_A \times 12}{0,2 \times 20}$ ✓ ✓ $= \frac{2}{1}$ ✓

c_A = 0,67 mol·dm^{-3} ✓

(4)

LEAVE OUT (FORMULA NOT GIVEN IN DATA SHEET)
Refer to conversion sheet for question 7

7.2.3 pH = -log[H_3O^+] ✓
= - log (0,67) ✓
= 0,17 ✓ ~~(3)~~

[16]

TOTAL: 100