

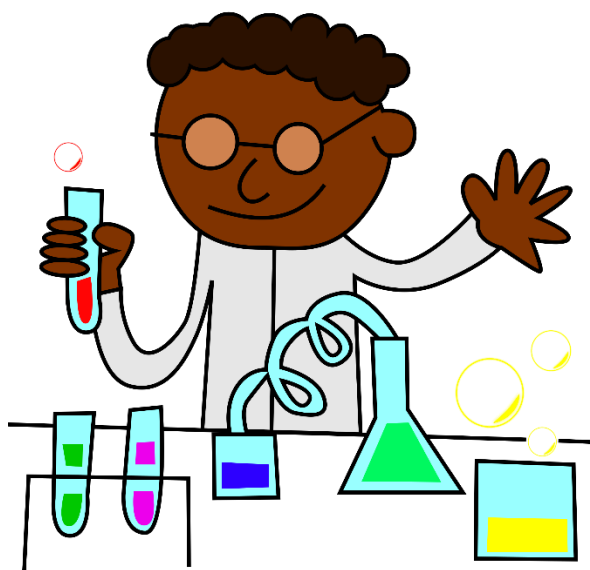


LABUAN MATRICULATION COLLEGE

GEAR UP YOUR POTENTIAL – ANSWER SCHEME

CHEMISTRY

2 hour



DO NOT OPEN THIS QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO.

This question paper consists of 6 questions. Answer all questions.

1. (a) Element **A** with atomic number 91, has 140 neutrons and 89 electrons. Write the isotopic notation for element **A**.

[1 mark]

(b)

Isotopes	Isotopic Masses (u)	Natural abundance
^{50}B	49.9658	1.8432
^{52}B	52.0056	35.5042
^{53}B	52.9867	4.0254
^{54}B	54.0021	1.00

Table 1

Element **B** has four naturally occurring isotopes, and their masses and natural abundances are shown in **Table 1** above. Calculate the average atomic mass of element **B**.

[2 marks]

- (c) Suberic acid is a colourless crystalline solid used in drug syntheses and plastics manufacture. The molar mass of suberic acid is 174 g mol^{-1} .

- (i) Suberic acid consists of 55.16% of carbon, 8.05% of hydrogen and 36.79% of oxygen. Determine the empirical formula and molecular formula of suberic acid.
- (ii) 20.0 g of suberic acid is dissolved in water to produce 500ml of solution with density 1.27 g ml^{-1} . Determine the molality of the solution.

[10 marks]

- (d) The reaction between 20 g of calcium nitride, Ca_3N_2 and 30 g of water produces calcium hydroxide and ammonia.

- (i) Write the chemical equation for the above reaction.
- (ii) Determine the limiting reactant.
- (iii) If the percentage yield of calcium hydroxide is produced from the above reaction is 72.35% with theoretical yield of 30 g, calculate the actual yield of calcium hydroxide formed.

[8 marks]

NO	PART	SCHEME	MARKS																					
1.	(a)	<div>${}_{91}^{231}\text{A}^{2+}$</div> <div>Correct nucleon and proton number & correct symbol and charge</div>	1	M1																				
	(b)	<div>Average atomic mass = $\frac{\Sigma Q_i M_i}{\Sigma Q_i}$ @</div> <div>$= \frac{(49.9658 \times 1.8432) + (52.0056 \times 35.5042) + (52.9867 \times 4.0254) + (54.0021 \times 1)}{(1.8432 + 35.5042 + 4.0254 + 1.00)}$</div> <div>= 52.0572 u @ a.m.u (unit insist!)</div>	1 1	M2 M3																				
	(c)(i)	<div>Assume 100% by mass = 100 g</div> <table><tr><th>Element</th><th>C</th><th>H</th><th>O</th></tr><tr><td>Mass (g)</td><td>55.16</td><td>8.05</td><td>36.79</td></tr><tr><td>Mole (mol)</td><td>$\frac{55.16}{12}$ = 4.5967</td><td>$\frac{8.05}{1}$ = 8.05</td><td>$\frac{36.79}{16}$ = 2.2994</td></tr><tr><td>Simplest Ratio</td><td>$\frac{4.5967}{2.2994}$ = 2 x 2 = 4</td><td>$\frac{8.05}{2.2994}$ = 3.5 x 2 = 7</td><td>$\frac{2.2994}{2.2994}$ = 1 x 2 = 2</td></tr><tr><td>Empirical Formula</td><td colspan="3">C₄H₇O₂</td></tr></table> <div>Molecular Formula = (Empirical Formula)_n $n = \frac{174}{87} = 2$ ∴ Molecular Formula = C₈H₁₄O₄</div>	Element	C	H	O	Mass (g)	55.16	8.05	36.79	Mole (mol)	$\frac{55.16}{12}$ = 4.5967	$\frac{8.05}{1}$ = 8.05	$\frac{36.79}{16}$ = 2.2994	Simplest Ratio	$\frac{4.5967}{2.2994}$ = 2 x 2 = 4	$\frac{8.05}{2.2994}$ = 3.5 x 2 = 7	$\frac{2.2994}{2.2994}$ = 1 x 2 = 2	Empirical Formula	C₄H₇O₂			1 1 1 1 1	M4 M5 M6 M7 M8 M9
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NO.	PART	SCHEME	MARKS	
	(c)(ii)	$\text{Mole of subaric acid} = \frac{m}{Mr} = \frac{20}{174} = 0.1149 \text{ mol}$ $\rho_{\text{solution}} = \frac{m_{\text{solution}}}{V_{\text{solution}}}$ $1.27 = \frac{m_{\text{solution}}}{500}$ $m_{\text{solution}} = 635 \text{ g}$ $m_{\text{solvent}} = 635 - 20 = 615 \text{ g}$ $\text{Molality} = \frac{\text{mol of solute}}{\text{mass of solvent (in kg)}} \quad @$ $= \frac{0.1149}{\left(\frac{615}{1000}\right)}$ $= 0.1868 \text{ m (unit insist!)}$	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p>	<p>M10</p> <p>M11</p> <p>M12</p> <p>M13</p> <p>M14</p>

[illegible]

2. (a) A line with a wavelength of 410.2 nm was observed in the Balmer series of the emission spectrum of hydrogen.

- Calculate its frequency.
- Determine the initial and final values of the energy levels associated with this emission.
- State the region of the electromagnetic spectrum in which the line is found.

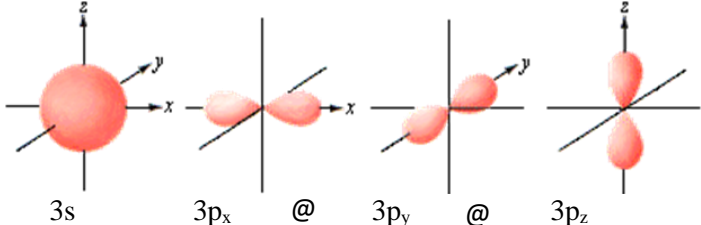
[5 marks]

- (b) An element **D** has proton number of 14

- Write the electronic configuration of an element **D**.
- Draw the shape of orbitals for the valence electron.
- What rule is used to arrange the 13th and 14th electron in element **D**?

[5 marks]

NO.	PART	SCHEME	MARKS	
2.	(a)(i)	$\nu = c/\lambda$ @	1	M1
		$= \frac{3.0 \times 10^8 \text{ ms}^{-1}}{410.2 \times 10^{-9} \text{ m}}$ $= 7.3135 \times 10^{14} \text{ s}^{-1}$	1	M2
	(a)(ii)	$n_{\text{final}} = 2$	1	M3
		$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right), n_1 < n_2$ @	1	M4
		$\frac{1}{410.2 \times 10^{-9}} = (1.097 \times 10^7) \left(\frac{1}{2^2} - \frac{1}{n_2^2} \right)$ Initial $n = n_2 = 6$	1	M5
	(a)(iii)	Visible region	1	M6

NO.	PART	SCHEME	MARKS	
	(b)(i)	$1s^2 2s^2 2p^6 3s^2 3p^2$	1	M7
	(b)(ii)	 <p>Draw 3s orbital (correct shape and axis) Draw any 2 out of 3 of 3p orbitals (correct shape and axis)</p>	1 1+1	M8 M9 M10
	(b)(iii)	Hund's Rule Correct spelling	1	M11
		TOTAL	11	
		MAX	10	

3. (a) Thiocyanic acid, HSCN, is an unstable gas that is used as a seed treatment for barley, cotton, corn and oats, and as a fungicide.

- Draw the Lewis structure of the three resonance structures of thiocyanate ion, SCN^- .
- Determine the most plausible structure and give your reason.

[8 marks]

- (b) Oxygen difluoride, OF_2 is a colourless poisonous gas.

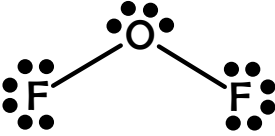
- Describe the hybridisation of central atom in OF_2 .
- Draw and state the molecular geometry of OF_2 .
- Predict the polarity of OF_2 .

[7 marks]

- (c) Explain why calcium has a higher boiling point than potassium.

[2 marks]

NO.	PART	SCHEME	MARKS	
3.	(a)(i)	<div>Structure I</div> $\left[\begin{array}{c} \text{:} \ddot{\text{S}} - \text{C} \equiv \text{N} \text{:} \end{array} \right]^{-}$ <div>Structure II</div> $\left[\begin{array}{c} \ddot{\text{S}} = \text{C} = \ddot{\text{N}} \end{array} \right]^{-}$ <div></div> $\left[\begin{array}{c} \text{:} \text{S} \equiv \text{C} - \ddot{\text{N}} \text{:} \end{array} \right]^{-}$ <div>Structure III</div>	<div>1</div> <div>1</div> <div>1</div>	<div>M1</div> <div>M2</div> <div>M3</div>
	(a)(ii)	<div>Formal charges for each structures:</div> <div><div>Structure I</div><div>S = 6 – 6 – ½ (2) = -1</div><div>C = 4 – 0 – ½ (8) = 0</div><div>N = 5 – 2 – ½ (6) = 0</div></div> <div><div>Structure II</div><div>S = 6 – 4 – ½ (4) = 0</div><div>C = 4 – 0 – ½ (8) = 0</div><div>N = 5 – 4 – ½ (4) = -1</div></div> <div><div>Structure III</div><div>S = 6 – 2 – ½ (6) = +1</div><div>C = 4 – 0 – ½ (8) = 0</div><div>N = 5 – 6 – ½ (2) = -2</div></div> <div>For each structure, correct FC OR show FC on the structure</div>	<div>1+1+1</div>	<div>M4</div> <div>M5</div> <div>M6</div>

		<p>Structure II is the most plausible structure.</p> <p>Because it has the lowest @ smallest formal charges and the negative formal charge appears on the more electronegative atom (N is more electronegative than S)</p>	1	M7
			1	M8
	(b)(i)	<p>G.S of O : $\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow \quad \uparrow \\ 2s \quad \quad 2p \end{array}$</p> <p>E.S of O : $\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow \quad \uparrow \\ 2s \quad \quad 2p \end{array}$</p> <p>H.S of O : $\begin{array}{c} \uparrow\downarrow \quad \uparrow\downarrow \quad \uparrow \quad \uparrow \\ \hline \text{sp}^3 \end{array}$</p> <p>Type of hybridisation of O in OF₂: sp³</p>	1	M9
			1	M10
			1	M11
			1	M12
	(b)(ii)	 <p>Molecular shape: bent @ V-shaped</p>	1	M13
			1	M14
	(b)(iii)	<p>Dipole moment cannot be cancelled out @ $\mu \neq 0$</p> <p>OF₂ is a polar molecule.</p>	1	M15
			1	M16
	(c)	<p>Ca has a greater no. of valence electron than K @</p> <p>Ca is smaller in size than K @</p> <p>Charge of Ca ion is greater than K ion</p> <p>Ca has a stronger metallic bond than K.</p>	1	M17
			1	M18
		TOTAL	18	
		MAX	17	

4. (a) A certain mass of fluorine gas is added to a vessel of 865 ml containing 1.3 g of argon gas. The gas pressure is increased from 811.5 mmHg to 1365.2 mmHg. Assuming the temperature remains constant, and that the fluorine gas does not react with argon gas, calculate the mass of the added fluorine gas.

[5 marks]

- (b) Butanal and butanol are amongst the chemical compound that exist in liquid phase. Explain which compound has a higher vapour pressure?

[4 marks]

NO.	PART	SCHEME	MARKS	
4.	(a)	$\begin{aligned} P_{F_2} &= P_T - P_{Ar} \\ &= 1365.2 - 811.5 \\ &= \textbf{553.7 mm Hg} \end{aligned}$ Mol of argon = $\frac{m}{Mr} = \frac{1.3}{40} = \textbf{0.0325 mol}$ $P_{F_2} = \frac{n_{F_2}}{n_T} \times P_T @$ $553.7 = \frac{x}{x + 0.0325} \times 1365.2$ x = 0.0222 mol Mass of fluorine gas = m x Mr @ = 0.0222 x 38 = 0.8436 g	<p align="center">1</p> <p align="center">1</p> <p align="center">1</p> <p align="center">1</p> <p align="center">1</p>	<p align="center">M1</p> <p align="center">M2</p> <p align="center">M3</p> <p align="center">M4</p> <p align="center">M5</p>
	(b)	<p>The IMF between butanal molecules are dipole-dipole forces, while butanol can form hydrogen bond between the molecules.</p> Dipole-dipole forces is a weaker IMF than hydrogen bond. Butanal is more volatile @ has a higher volatility than butanol @ butanal easier to vaporise than butanol. Butanal has a higher vapour pressure than butanol.	<p align="center">1</p> <p align="center">1</p> <p align="center">1</p> <p align="center">1</p>	<p align="center">M6</p> <p align="center">M7</p> <p align="center">M8</p> <p align="center">M9</p>
		TOTAL	9	

5. (a) Oxidation of sulphur dioxide to sulphur trioxide is a reversible reaction.



In one experiment, at 750 °C, an equilibrium was achieved in a closed vessel with partial pressures of SO_2 , O_2 and SO_3 are 0.27, 0.40 and 0.32 atm respectively.

- (i) Calculate the equilibrium constant, K_p .
 (ii) Determine the initial pressures of SO_2 and O_2 .

[6 marks]

- (b) The equilibrium for the formation of ammonia gas, NH_3 , is represented by the equation:



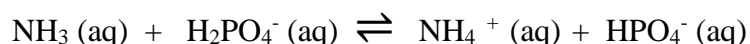
Explain the effect on the amount of NH_3 and the value of K_p if the temperature is decreased.

[3 marks]

NO.	PART	SCHEME	MARKS																	
5.	(a)(i)	$K_p = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]^2} \quad @$ $= \frac{(0.32)^2}{(0.27)^2(0.40)}$ $K_p = \mathbf{3.51} \text{ (at 750 } ^\circ\text{C)}$	1 1	M1 M2																
	(a)(ii)	<table border="1"><tr><td colspan="4">$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$</td></tr><tr><td>P_{initial} (atm)</td><td>a</td><td>b</td><td>0</td></tr><tr><td>P_{change} (atm)</td><td>-2x</td><td>-x</td><td>+2x</td></tr><tr><td>P_{equilibrium} (atm)</td><td>a-2x = 0.27</td><td>b-x = 0.40</td><td>2x = 0.32</td></tr></table> <p>From P_{SO₃} at equilibrium, 2x = 0.32 x = 0.16</p> <p>At initial, P_{SO₂} = a a - 2x = 0.27 a - 2(0.16) = 0.27 a = 0.59 atm = P_{SO₂}</p>	$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$				P _{initial} (atm)	a	b	0	P _{change} (atm)	-2x	-x	+2x	P _{equilibrium} (atm)	a-2x = 0.27	b-x = 0.40	2x = 0.32	1 (ICE Table) 1 1	M3 M5
$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$																				
P _{initial} (atm)	a	b	0																	
P _{change} (atm)	-2x	-x	+2x																	
P _{equilibrium} (atm)	a-2x = 0.27	b-x = 0.40	2x = 0.32																	

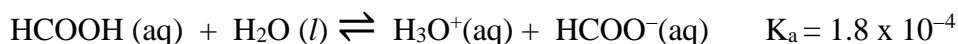
		At initial, $P_{O_2} = b$ $b - x = 0.40$ $b - 0.16 = 0.40$ $b = \mathbf{0.56\ atm} = P_{O_2}$	1	M6
	(b)	Since the reaction is exothermic , the equilibrium position shifts to the right . The amount of NH_3 will increase . The value of K_p increase	1 1 1 1	M7 M8 M9 M10
		TOTAL	10	
		MAX	9	

6. (a) Identify the Bronsted-Lowry acid-base and their conjugates pair in the equation below.



[2 marks]

- (b) Formic acid, HCOOH , is the irritant that causes the body's reaction to ant stings. The ionisation of formic acid is as follows:



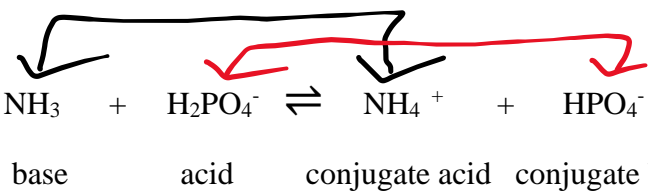
- (i) Calculate the concentration of HCOO^- ion in 0.186 M solution of HCOOH .
 (ii) What is the pH of this solution?

[5 marks]

- (c) A student is asked to prepare a buffer solution at pH 9.6 using 50.00 mL of 0.25 M propylamine, $\text{C}_3\text{H}_7\text{NH}_2$ and propylammonium chloride, $\text{C}_3\text{H}_7\text{NH}_3\text{Cl}$. The K_b value of $\text{C}_3\text{H}_7\text{NH}_2$ is 4.7×10^{-4} .

- (i) Calculate the mass propylammonium chloride required to prepare the buffer solution.
 (ii) Write the chemical equation of the buffering effect when a small amount of HCl and NaOH is added into the buffer solution respectively.

[7 marks]

NO.	PART	SCHEME	MARKS																
7	(a)	 <p style="text-align: center;"> $\text{NH}_3 + \text{H}_2\text{PO}_4^- \rightleftharpoons \text{NH}_4^+ + \text{HPO}_4^-$ base acid conjugate acid conjugate base </p> <p style="text-align: right;">show pair of base + c.acid</p> <p style="text-align: right;">show pair of acid + c.base</p>	1 1	M1 M2															
	(b)(i)	<p style="text-align: center;">$\text{HCOOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{HCOO}^-(\text{aq})$</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>[]i</td><td>0.186</td><td>-</td><td>0</td><td>0</td></tr> <tr> <td>[]c</td><td>-x</td><td>-</td><td>+ x</td><td>+ x</td></tr> <tr> <td>[]e</td><td>0.186- x</td><td>-</td><td>x</td><td>x</td></tr> </table>	[]i	0.186	-	0	0	[]c	-x	-	+ x	+ x	[]e	0.186- x	-	x	x	1	M3
[]i	0.186	-	0	0															
[]c	-x	-	+ x	+ x															
[]e	0.186- x	-	x	x															

		$K_a = \frac{[H_3O^+][HCOO^-]}{[HCOOH]} \quad @$ $1.8 \times 10^{-4} = \frac{x^2}{0.186 - x}$ <p>Solve x quadratically</p> <p>x = 5.6969 x 10⁻³ (accepted) , -5.8769 x 10⁻³ (rejected)</p> <p>x = [HCOO⁻] = 5.6969 x 10⁻³ M</p>	1	M4
			1	M5
			1	M6
	(b)(ii)	<p>[H₃O⁺] = 5.6969 x 10⁻³</p> <p>pH = - log[H₃O⁺] = - log (5.6969 x 10⁻³)</p> <p>= 2.2444</p>	1	M7
			1	M8
	(c)(i)	<p>pOH = 14 – pOH</p> <p>= 14 – 9.6 = 4.4</p> <p>pOH = pK_b + log $\frac{[salt]}{[weak\ base]}$</p> <p>pOH = pK_b + log $\frac{[C_3H_7NH_3Cl]}{[C_3H_7NH_2]} \quad @$</p> <p>4.4 = - log (4.7 x 10⁻⁴) + log $\frac{[C_3H_7NH_3Cl]}{0.25}$</p> <p>[C₃H₇NH₃Cl] = 2.9515 M</p> <p>mol of C₃H₇NH₃Cl = $\frac{2.9515 \times 50}{1000}$</p> <p>= 0.1476 mol</p> <p>mass of C₃H₇NH₃Cl = m x Mr</p> <p>= 0.1476 x 95.5</p> <p>= 14.0958 g</p>	1	M9
			1	M10
			1	M11
			1	M12
			1	M13
	(c)(ii)	<p>When HCl is added:</p> <p>C₃H₇NH₂ (aq) + H⁺ (aq) → C₃H₇NH₃⁺ (aq)</p> <p>When NaOH is added:</p> <p>C₃H₇NH₃⁺ (aq) + OH⁻ (aq) → C₃H₇NH₂ (aq) + H₂O (l)</p> <p>Both equations, phases are insisted</p>	1	M14
			1	M15
		TOTAL	15	
		MAX	14	