ANSWER SCHEME
TEST 3
SK015
Chemistry 1
Semester 1
Session 2023/2024

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CHEMISTRY UNIT
PAHANG MATRICULATION COLLEGE

ANSWER SCHEME
TEST 3
CHAPTER 1, 2, 4, 5, 6 & 7

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<table>
<tr><th>NO.</th><th>PART</th><th>SCHEME</th><th>MARKS</th><th></th></tr>
<tr><td>1.</td><td>(a)</td><td>Average atomic mass of Mg = $\frac{\sum Q_i m_i}{\sum Q_i}$

@

$24.31 = \frac{(78.99 \times 23.985)+(X \times 24.986)+(11.01 \times 25.983)}{78.99 + X + 11.01}$

$X = 10.72\ \%$

Percentage abundance of ^{25}Mg = 10.72 %</td><td>1

1</td><td>M1

M2</td></tr>
<tr><td></td><td>(b)</td><td>Mass C = $\frac{12.0\text{ g C}}{44.0\text{ g } CO_2} \times 1.503\text{ g } CO_2$ = 0.410 g

Mass H = $\frac{2.0\text{ g H}}{18.0\text{ g } H_2O} \times 0.414\text{ g } H_2O$ = 0.046 g

Mass O = mass of sample – (mass of C + mass of H)
= 1.001 g – (0.410 + 0. 046) g
= 0.545 g

&

<table>
<tr><th>Element</th><th>C</th><th>H</th><th>O</th></tr>
<tr><td>Mass/g</td><td>0.410</td><td>0.046</td><td>0.545</td></tr>
<tr><td>Amount/mol</td><td>$\frac{0.410}{12.0}$ = 0.034</td><td>$\frac{0.046}{1.0}$ = 0.046</td><td>$\frac{0.545}{16.0}$ = 0.034</td></tr>
<tr><td rowspan="2">Simplest ratio</td><td>$\frac{0.034}{0.034}$ = 1</td><td>$\frac{0.046}{0.034}$ = 1.35</td><td>$\frac{0.034}{0.034}$ = 1</td></tr>
<tr><td>1 x 3 = 3</td><td>1.35 x 3 = 4</td><td>1 x 3 = 3</td></tr>
</table>

Empirical formula = $C_3H_4O_3$</td><td>1

1

1

1</td><td>M3

M4

M5

M6</td></tr>
<tr><td></td><td>(c)</td><td>Assume; Mass $_{solution}$ = 100 g

$\%\,w/w = \frac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100\ \%$

$47.5\ \% = \frac{\text{mass of solute}}{100\text{ g}} \times 100\ \%$

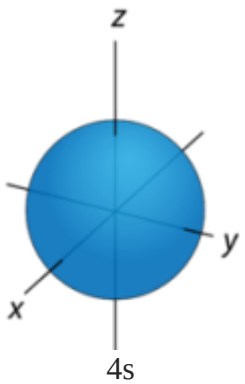
&

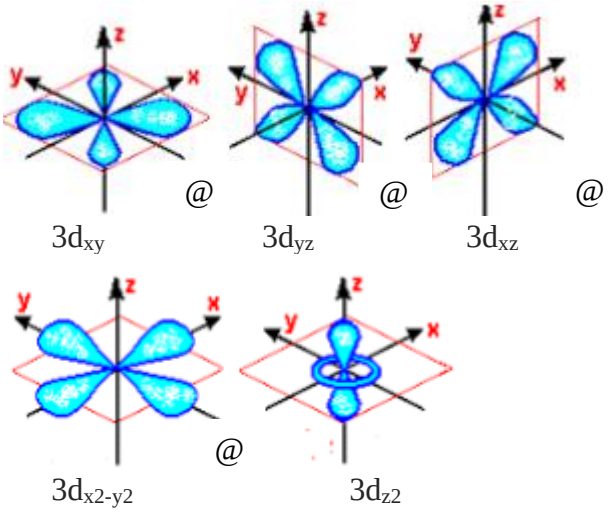
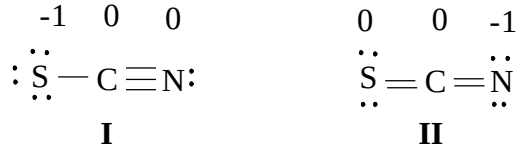
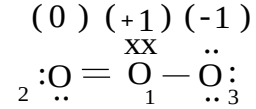
$\therefore$ Mass $_{solute\ (HBr)}$ = 47.5 g

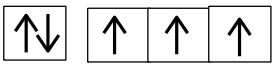
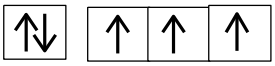
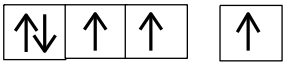
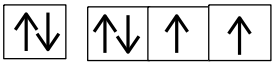
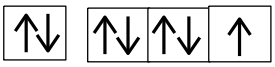
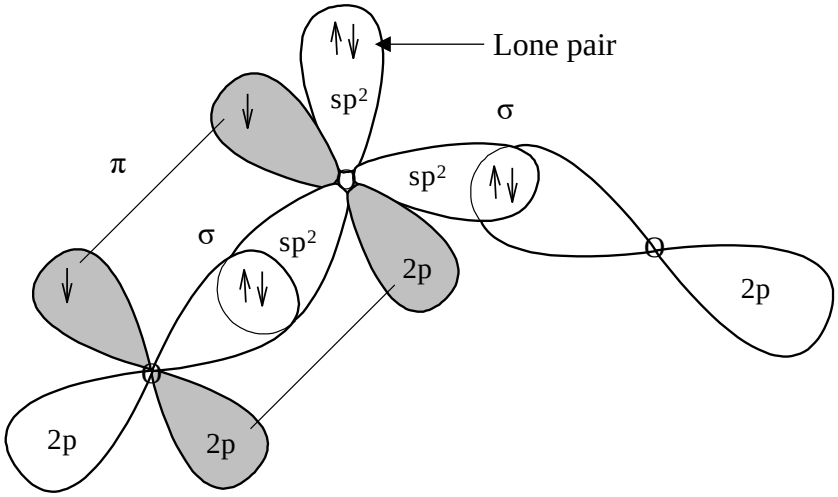
@

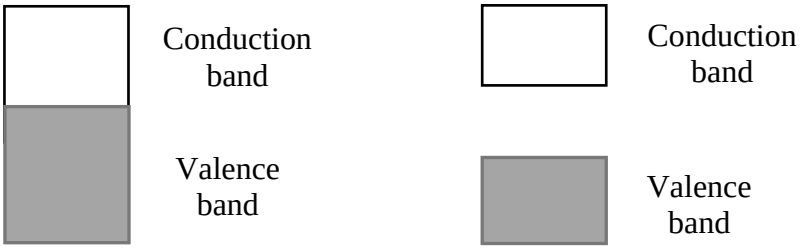
Assume 47.5 g HBr in 100 g solution</td><td>1</td><td>M7</td></tr>
</table>

		$n_{\text{solute (HBr)}} = \dfrac{\text{Mass}_{\text{solute (HBr)}}}{\text{Molar mass}_{\text{solute (HBr)}}}$ $n_{\text{solute (HBr)}} = \dfrac{47.5\text{ g}}{(79.9 + 1.0)\text{ g mol}^{-1}}$ $= \mathbf{0.587\text{ mol}}$	**1**	**M8**
		$\text{Mass}_{\text{solution}} = \rho_{\text{solution}} \times V_{\text{solution}}$ $100\text{ g} = 1.30\text{ g cm}^{-3} \times V_{\text{solution}}$ $V_{\text{solution}} = \mathbf{76.923\text{ cm}^3}$	**1**	**M9**
		$\text{Molarity} = \dfrac{n_{\text{solute (HBr)}}}{V_{\text{solution}}\ (\text{dm}^3)}$ $= \dfrac{0.587\text{ mol}}{0.0769\text{ dm}^3}$ $= \mathbf{7.63\text{ M}}$	**1**	**M10**
	(d)	$MnO_4^-(aq) + SO_3^{2-}(aq) \rightarrow MnO_2(aq) + SO_4^{2-}(aq)$ Oxidation: $SO_3^{2-} \rightarrow SO_4^{2-}$ Reduction: $MnO_4^- \rightarrow MnO_2$ } & ($SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e$) x 3 ($MnO_4^- + 4H^+ + 3e \rightarrow MnO_2 + 2H_2O$) x 2 } & $3SO_3^{2-}(aq) + 2MnO_4^-(aq) + 2H^+(aq) \rightarrow 3SO_4^{2-}(aq) + 2MnO_2(aq) + H_2O(\iota)$	**1** **1** **1**	**M11** **M12** **M13**
	(e) (i)	n_{NH_3} available = 0.62 mol n_{CO_2} available = 0.56 mol From equation; 2 mol $NH_3 \equiv$ 1 mol CO_2 0.62 mol $NH_3 \equiv$ **0.31 mol CO_2 (required)** Since mole CO_2 available (0.56 mol) is **more than** mole CO_2 required (0.31 mol), CO_2 present in excess. ∴ **NH_3 is the limiting reactant.** @ 1 mol $CO_2 \equiv$ 2 mol NH_3 0.56 mol $CO_2 \equiv$ **1.12 mol NH_3 (required)** Since mole NH_3 available (0.62 mol) is **less than** mole NH_3 required (1.12 mol), NH_3 present in limits. ∴ **NH_3 is the limiting reactant.**	**1** **1** **1**	**M14** **M15** **M16**

	(e) (ii)	2 mol $NH_3 \equiv$ 1 mol $(NH_2)_2CO$ 0.62 mol $NH_3 \equiv$ **0.31 mol $(NH_2)_2CO$ (required)** Mass of $(NH_2)_2CO$ = 0.31 mol x (2[14.0 + 2(1.0)] + 12.0 + 16.0) g mol^{-1} = **18.60 g**	**1** **1** **1**	**M17** **M18** **M19**
	(e) (iii)	2 mol $NH_3 \equiv$ 1 mol CO_2 0.62 mol $NH_3 \equiv$ **0.31 mol CO_2 (required)** n_{CO2} remained = n_{CO2} available – n_{CO2} required = 0.56 mol – 0.31 mol = **0.25 mol** $Mass_{CO2}$ remained after the reaction = 0.25 mol x [12.0 + 2(16.0)] g mol^{-1} = **11.00 g**	**1** **1** **1**	**M20** **M21** **M22**
			TOTAL **22**	
			MAX **21**	
2.	**(a) (i)**	$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$, $n_1 < n_2$ @ $= (1.097 \times 10^7\ m^{-1})\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$ $\lambda = 1.02555 \times 10^{-7} \times 10^9$ nm = **102.55 nm**	 **1** **1**	 **M1** **M2**
	(a) (ii)	$E_n = -R_H\left(\frac{1}{n^2}\right)$ @ $= -2.18 \times 10^{-18}\left(\frac{1}{2^2}\right)$ = **-5.45×10^{-19} J**	 **1** **1**	 **M3** **M4**
	(b) (i)	(n, l, m, s) : (3, 0, 0, -1/2) @ (3, 0, 0, +1/2)	**1**	**M5**
	(b) (ii)	4s and 3d orbital  4s	**1**	**M6**

		 $3d_{xy}$ @ $3d_{yz}$ @ $3d_{xz}$ $3d_{x^2-y^2}$ @ $3d_{z^2}$ * **Any 3d** orbital with **correct label**	**1**	**M7**
	(b) (iii)	Hund's Rule	**1**	**M8**
	(c)	Actual electronic configuration of copper is **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$.** It is because **fully-filled 3d orbital is more stable than partially-filled 3d orbital.**	**1** **1**	**M9** **M10**
		TOTAL	**10**	
3.	**(a) (i)**	 **I** **II**	**1** (I & II correct)	**M1**
	(a) (ii)	**Structure II** is the most plausible structure because the negative **formal charge is on the more electronegative nitrogen atom.**	**1** **1**	**M2** **M3**
	(b)	Valence electrons: O : 3 x 6 = **18** - 4 14 -12 2 - 2 0	**1**	**M4**
		@	**1**	**M5**
		Formal charge O in O_3 : FC O_1= 6 – [2 +1/2(6)] = +1 FC O_2= 6 – [4 +1/2(4)] = 0 FC O_3= 6 – [6 +1/2(2)] = -1 @  written in structure	**1**	**M6**

		Hybridisation process in O_3 : **Central atom** Ground state of O_1^+ :  2s 2p Excited state of O_1^+ :  2s 2p &	**1**	**M7**
		Hybrid state of O_1^+ :  sp^2 2p unhybridized	**1**	**M8**
		Terminal atom Ground state of O_2 :  2s 2p Ground state of O_3^- :  2s 2p &	**1**	**M9**
				
		* Correct **shape and label of sp^2 hybrid orbital of O (Central atom)**	**1**	**M10**
		* Show **e**, label **O**, **2σ, 1π, 3 sp^2 orbital** and **2p.**	**1**	**M11**
		* Molecular shape: **V-shape @ Bent**	**1**	**M12**
		Explanation:		
		* **sp^2 hybrid orbital of O** overlap end to end with **2p orbital of O** to form **2σ bond** and occupied **one lone pair.**	**1**	**M13**
		*** 2p orbital of O overlap side by side with 2p orbital of O to form 1π.**	**1**	**M14**
	(c)	NCl_3 has **higher** boiling point than **BCl_3** because **NCl_3 is a polar molecule** while **BCl_3 is a non-polar molecule**.	**1**	**M15**
		Dipole-dipole forces between NCl_3 molecules is **stronger than London forces @ dispersion forces** between BCl_3 molecule.	**1**	**M16**

	(d)	Copper, **Cu is a metal** while carbon, **C is a non-metal.**  **Metal, Cu** **Non-metal, C** @	**1**	**M17**
		There is **no band gap between valence band and conduction band** in Cu. Whereas a **large gap between valence band and conduction band** in C.	**1**	**M18**
		Thus, **electrons** can move **freely from valence band to conduction band of Cu to carry electricity** while **C does not**.	**1**	**M19**
		TOTAL	**19**	
		MAX	**17**	
4.	**(a)**	By using Boyle's Law: $P_1V_1 = P_2V_2$ $(1.2\ atm)(120\ mL) = P_2(180\ mL)$ } @ P_2 **= 0.8 atm**	**1** **1**	**M1** **M2**
	(b)	By using ideal gas equation: $P_{CO_2}V = n_{CO_2}RT$ $P_{CO_2} = \frac{mRT}{VMr}$ $= \frac{(5.50\ g)(0.08206\ Latmmol^{-1}K^{-1})(297.15\ K)}{(10.0\ L)(44.0\ gmol^{-1})}$ } @ **= 0.305 atm** By using Dalton's Law: $P_T = P_{air} + Pco_2$ $= 0.928\ atm + 0.305\ atm$ P_T **= 1.23 atm** 760 torr ≡ 1 atm 705 torr ≡ 0.928 atm	**1** **1**	**M3** **M4**
	(c) (i)	**CH_3CH_2OH , CH_3OH , CH_3CHO** ⟶ Increasing vapour pressure	**1**	**M5**
	(c) (ii)	The **weaker the intermolecular forces** of the liquid molecules**, the higher the vapour pressure** @ **vice versa.**	**1**	**M6**
	(d) (i)	Phase diagram of water, **H_2O** has **negative slope** while phase diagram of carbon dioxide, **CO_2** has **positive slope**.	**1**	**M7**

		@ Freezing/melting curve **of H_2O slope to the left** while freezing/melting curve **of CO_2 slope to the right**.		
	(d) (ii)	It is because **ice is less dense** (occupy larger volume) **than water.** @ It is because **solid H_2O is less dense** (occupy larger volume) **than liquid H_2O.**	**1**	**M8**
	(d) (iii)	The **kinetic energy** of the water vapour **decreases**.	**1**	**M9**
		TOTAL	**9**	
5.	**(a)**	$Qc = \frac{[SO_3]^2}{[SO_2]^2\,[O_2]}$ $= \frac{(10)^2}{(0.010)^2\,(0.010)}$ @ $= \mathbf{1.0 \times 10^8}$ **Qc > Kc** The **mixture is not at equilibrium** because: - the ratio of **initial concentration of product is too large**. - **product must be converted into reactant**. The reaction is proceeded from **right to left**.	**1** **1** **1** **1** **1** **1** **1**	**M1** **M2** **M3** **M4** **M5** **M6** **M7**
	(b)	This reaction is exothermic. Decreasing temperature causes the **equilibrium position shift to right** to re-establish the equilibrium. Therefore, **the amount of SO_2 and O_2 decrease** and **the amount of SO_3 increase** until the equilibrium is reached.	**1** **1**	**M8** **M9**
		TOTAL	**9**	
6.	**(a) (i)**	$pH = -\log [H^+]$ $1.85 = -\log [H^+]$ **$[H^+] = x = 0.0141$ M**	**1**	**M1**
			1 (Eq + phase)	**M2**
			1	**M3**
		$K_a = \frac{[NO_2^-]\,[H^+]}{[HNO_2]}$ $= \frac{(0.0141)^2}{(0.235-0.0141)}$ @ **$= 9.00 \times 10^{-4}$**	**1** **1**	**M4** **M5**

Concentration (M)	$HNO_2(aq)$	$\rightleftharpoons$ $NO_2^-(aq)$ +	$H^+(aq)$
Initial	0.235	0	0
Change	- x	+ x	+ x
Equilibrium	0.235-x	x	x

(a) (ii)

Concentration (M)	$HNO_2(aq)$ +	$OH^-(aq)$ →	$NO_2^-(aq)$ +	$H_2O(\iota)$
Initial	0.235	$\frac{(0.01\ mol)}{(1\ L)} = 0.01$	0.240	-
Change	-0.01	-0.01	+0.01	-
Equilibrium	0.225	0	0.250	-

1 **M6**

1 **M7**

$$pH = pK_a + \log\left[\frac{NO_2^-}{HNO_2}\right]$$

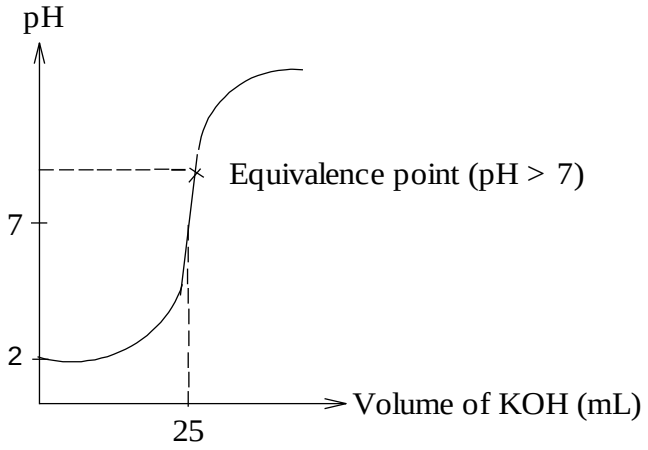
$$= -\log(9.00 \times 10^{-4}) + \log\frac{(0.250)}{(0.225)}$$ @

1 **M8**

$$= \mathbf{3.09}$$

1 **M9**

(b)



Axis 1 (pH & Vol KOH) **M10**

1 (Shape + Eq. point) **M11**

(c)

Concentration (M)	$Ag_2SO_4(s)$ ⇌	$2Ag^+(aq)$ +	$SO_4^{2-}(aq)$
Initial	-	0	0
Change	-	+2s	+s
Equilibrium	-	2s	s

1 **M12**

$[Ag^+] = 2s = 1.5 \times 10^{-2}$ M

$\therefore s = \mathbf{7.5 \times 10^{-3}\ M}$

1 **M13**

$$K_{sp} = [Ag^+]^2 [SO_4^{2-}]$$

$$= (2s)^2 (s)$$ @

$$= 4s^3$$

$$= 4 (7.5 \times 10^{-3})^3$$

1 **M14**

$$= \mathbf{1.69 \times 10^{-6}}$$

1 **M15**

TOTAL	**15**	
MAX	**14**	

PREPARED BY:	REVISED BY:	APPROVED BY:
_____	_____	_____
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