<table>
<tr><th>NO</th><th>ANSWER SCHEME</th><th>MARK</th></tr>
<tr><td>1 (a) (i)</td><td>

$$\text{Average atomic mass} = \frac{\sum(\% \text{ relative abundannce x isotopic mass})}{\sum(\text{relative abundance})}$$

@

$$= \frac{(4.85 \text{ x } 6) + (95.15 \text{ x } 7)}{4.85 + 95.15}$$

= 6.95 amu

$$\text{Relative atomic mass} = \frac{6.95 \text{ amu}}{\frac{1}{12} \text{ x } 12 \text{ amu}}$$

= **6.95**

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1</td></tr>
<tr><td>1 (a) (ii)</td><td>Lithium @ Li</td><td>1</td></tr>
<tr><td>1 (b)</td><td>

Mass of Oxygen = 31.64 – 7.85 – 10.98 = 12.81 g

<table>
<tr><td>Element</td><td>K</td><td>Mn</td><td>O</td></tr>
<tr><td>Mass (g)</td><td>7.85</td><td>10.98</td><td>12.81</td></tr>
<tr><td>Mole (mol)</td><td>7.85/39.1 = 0.2008</td><td>10.98/54.9 = 0.2000</td><td>12.81/16 = 0.8006</td></tr>
<tr><td>Mole ratio</td><td>0.2008/0.2000 = 1.004 ≈ 1.0</td><td>0.2000/0.2000 = 1.0</td><td>0.8006/0.2000 = 4.003 ≈ 4.0</td></tr>
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Empirical formula = **$KMnO_4$**

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<tr><td>1 (c)</td><td>

V solution = 1 L = 1000 mL
Mass $Mg(NO_3)_2$ = 292 g

No. of mole of $Mg(NO_3)_2 = \frac{292 \text{ g}}{148.3 \text{ g/mol}}$ = 1.969 mol

Mass of solution = 1.18 g mL^{-1} x 1000 mL = 1180 g

@

Mass of solvent = 1180 g – 292 g = 888 g = 0.888 kg

Molality = $\frac{Mole\ of\ Mg\ (NO_3)_2}{Mass\ of\ solvent\ (kg)}$

@

$= \frac{1.969\ mol}{0.888\ kg}$

= **2.22 m**

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1</td></tr>
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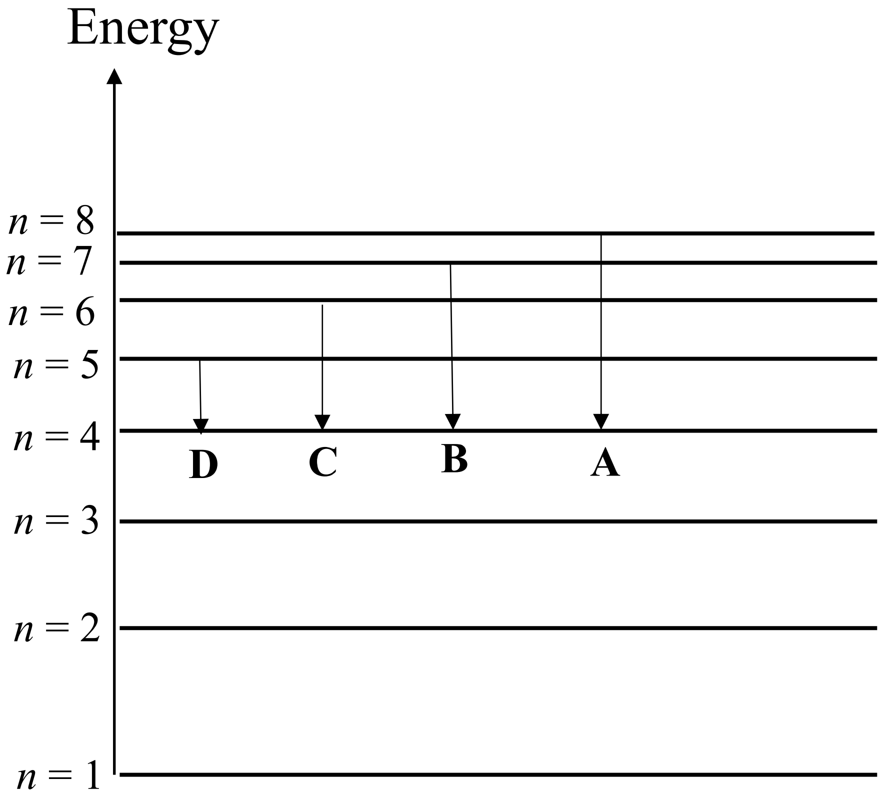
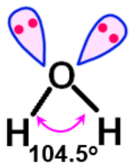
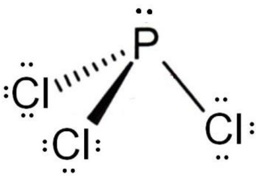
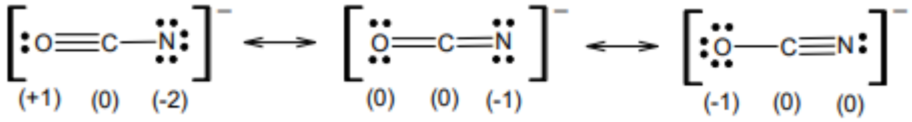
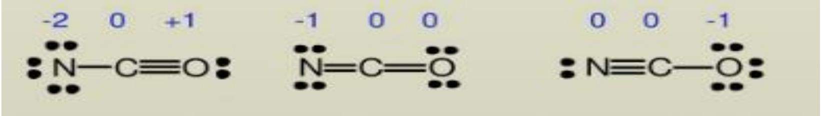
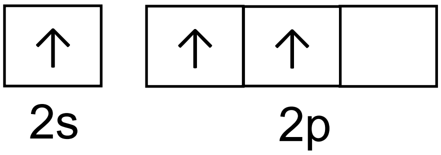
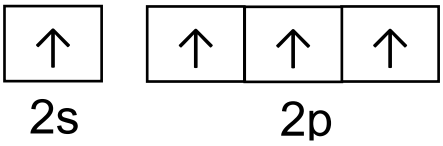
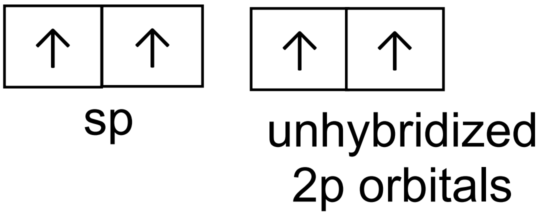
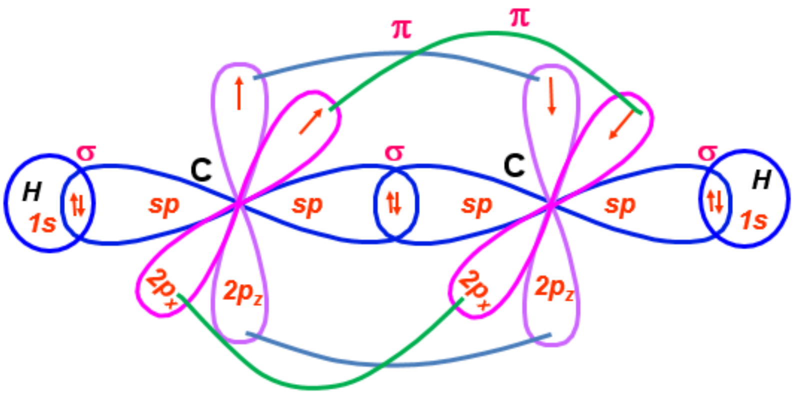
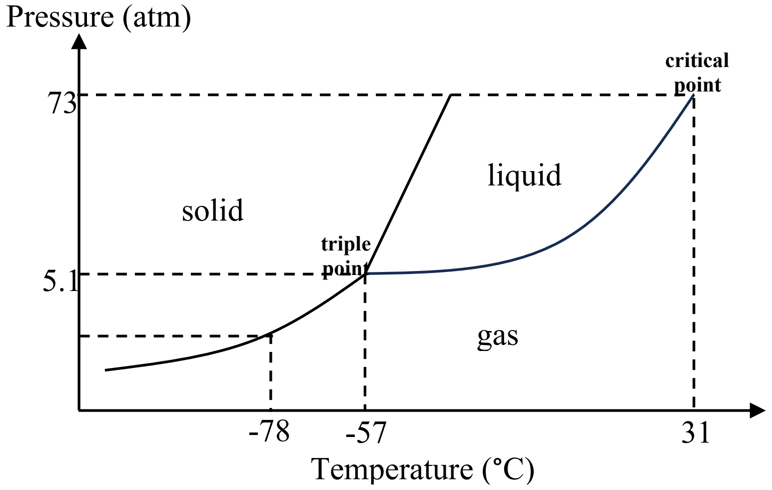
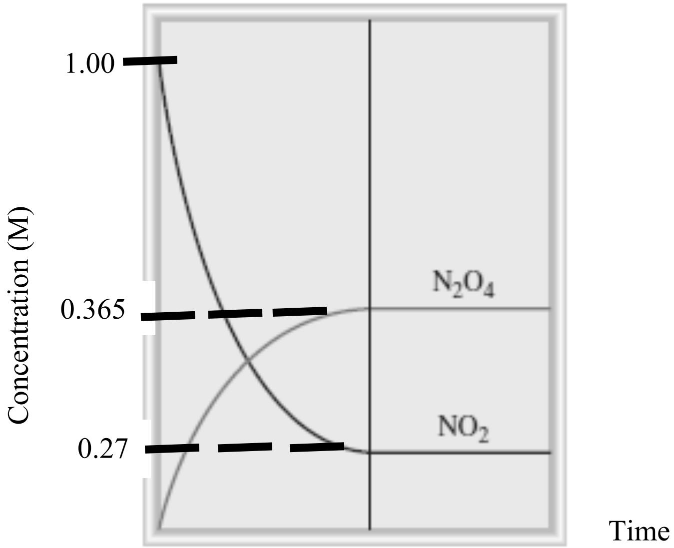
	% w/w = $\frac{\text{Mass of } Mg\,(NO_3)_2}{\text{Mass of solution}}$ x 100 @ = $\frac{292\text{ g}}{1180\text{ g}}$ x 100	1
	= **24.75 %**	1
1 (d) (i)	No. of mole of $NaHCO_3$ = $\frac{1.0\ g}{84\ g/mol}$ = 0.0119 mol @ No. of mole of $H_3C_6H_5O_7$ = $\frac{1.0\ g}{192\ g/mol}$ = 5.208 x 10^{-3} mol	1
	3 mol $NaHCO_3$ ≡ 1 mol $H_3C_6H_5O_7$ 0.0119 mol $NaHCO_3$ ≡ 3.9667 x 10^{-3} mol $H_3C_6H_5O_7$	1
	Moles of $H_3C_6H_5O_7$ needed < moles of $H_3C_6H_5O_7$ given $H_3C_6H_5O_7$ is excess reactant $NaHCO_3$ is limiting reactant	1
	3 mol $NaHCO_3$ ≡ 3 mol CO_2 0.0119 mol $NaHCO_3$ ≡ 0.0119 mol CO_2	1
	Mass of CO_2 = 0.0119 mol x 44 g/mol = 0.5236 g	1
	Alternative Answer	
	3 mol $NaHCO_3$ ≡ 3 mol CO_2 0.0119 mol $NaHCO_3$ ≡ 0.0119 mol CO_2 1 mol $H_3C_6H_5O_7$ ≡ 3 mol CO_2 5.208 x 10^{-3} mol $H_3C_6H_5O_7$ ≡ 0.0156 mol CO_2	1
	$NaHCO_3$ produce less product. $NaHCO_3$ is limiting reactant	1
	Mass of CO_2 = 0.0119 mol x 44 g/mol	1
	= **0.5236 g**	1
1 (d) (ii)	Moles of $H_3C_6H_5O_7$ in excess = 5.208 x 10^{-3} mol - 3.9667 x 10^{-3} mol	1
	= 1.2413 x 10^{-3} mol	1
	Mass of $H_3C_6H_5O_7$ in excess = 1.2413 x 10^{-3} mol x 192g/mol = **0.2383 g**	1
	TOTAL **MAX**	**22** **21**

NO	ANSWER SCHEME	MARK
2 (a) (i)	The line B of electron transition from **n = 8** to **n = 4**	1
(ii)	$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right), n_1 < n_2$ @ $\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{4^2} - \frac{1}{8^2}\right)$ $\boldsymbol{\lambda = 1.944 \times 10^{-6}\ m}$	 1 1
(iii)		Axis – 1 Energy level – 1 Line ABCD - 1
(b)(i)	expected configuration $_{24}Cr$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$ actual configuration $_{24}Cr$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$	1 1
(ii)	The reason for anomaly: Half-filled 3d orbitals ($3d^5$) are stable compared with partially filled 3d orbitals.	1
(iii)	(n,l,m,s) = **(4, 0, 0, +1/2)** or **(4, 0, 0, -1/2)**	1
	TOTAL	**10**

NO	ANSWER SCHEME	MARK
1.	  PCl_3 has **lone pair - bonding pair repulsion** while and H_2O **has lone pair - lone pair repulsion** **Lone pair - lone pair repulsion is stronger than lone pair - bonding pair repulsion** Thus, H_2O has bond angle lesser than PCl_3.	1 + 1 1 1
2.i	 I II III OR  I II III	4 (3 structures + 1 formal charge)
ii.	**III** Reason : **negative formal charge is at the highly electronegative atom** which is O.	1 1
3.i	Electron groups: **2** Type of hybridization: **sp**	1 1
ii.	Valence electron of C Ground state : 	

	Promotion of electron: 	1
	sp hybridization: 	1
		
	Shape and sp linear	1
	Correct σ and π bonds	1
	Label all orbitals	1
	TOTAL	**17**

NO	ANSWER SCHEME	MARK
4(a)(i)	$P_1V_1 = nRT_1$ $V_1 = \frac{0.35 \times 0.08206 \times 286.15}{0.747}$ $= 11.0\ L$ $P_2V_2 = nRT_2$ $V_2 = \frac{0.35 \times 0.08206 \times 329.15}{1.18}$ $= 8.0\ L$ $\Delta V = 11.0 - 8.0 = \mathbf{3.0\ L}$	 1 1 1
4(a)(ii)	At low temperature, **average kinetic energy decreases**. Argon gas particles **move at low speed and the intermolecular forces become significant**. Therefore, it deviates from the ideal gas behaviour.	1
4(b)	**Diethyl ether** is the most volatile liquid. It has **the weakest intermolecular forces between its molecules and the higher the vapor pressure**. **Less energy is needed to break the bond** and turn into gaseous. Therefore, diethyl ether has the lowest boiling point at 760 torr.	1 1
4(c)(i)		Axis and label – 1 Curve (positive slope) – 1
4(c)(ii)	**Water (liquid state) has higher density because the melting point of ice decreases with pressure** and occupied smaller volume than the ice (solid state)	1
	TOTAL	**9**

NO	ANSWER SCHEME	MARK
5 (a)	$K_p = K_c (RT)^{\Delta n}$ @ $= 5(0.08206 \times 373)^{-1}$ **K_p = 0.163**	1 1
(b)	$\begin{array}{lcc} & 2NO_2(g) & \rightleftharpoons N_2O_4(g) \\ \text{Initial(M)} & 1 & 0 \\ \text{Change(M)} & -2x & +x \\ \text{Equilibrium(M)} & 1-2x & x \end{array}$ $Kc = \frac{[N_2O_4]}{[NO_2]^2}$ @ $5 = \frac{x}{(1-2x)^2}$ $5 - 21x + 20x^2 = 0$ $x = 0.685$ (neglected) $x = 0.365$ **$[N_2O_4]$ = 0.365 M**	1 1 1
(c)		Axis - 1 Curve N_2O_4 and NO_2 - 1 Equilibrium line: 1
(d)	- the **temperature is increased,** the system will reduce the disturbance by decreasing the temperature @ **favour endothermic**, - hence the **equilibrium position will shift to the left**	1 1
	TOTAL **MAX**	**10** **9**

<table>
<tr><th>NO</th><th>ANSWER SCHEME</th><th>MARK</th></tr>
<tr><td>6(a)(i)</td><td>
<table>
<tr><td colspan="5">C_5H_5N (aq) + H_2O (l) ⇌ $C_5H_5NH^+$ (aq) + OH^- (aq)</td></tr>
<tr><td>$[\ ]_i$ / M</td><td>0.60</td><td>-</td><td>0</td><td>0</td></tr>
<tr><td>Δ[ ] / M</td><td>-x</td><td>-</td><td>+ x</td><td>+x</td></tr>
<tr><td>$[\ ]_{eq}$ / M</td><td>0.60 - x</td><td>-</td><td>x</td><td>x</td></tr>
</table>

$K_b = \frac{[C_5H_5NH^+][OH^-]}{[C_5H_5N]}$
@ $1.70 \times 10^{-9} = \frac{(x)^2}{(0.60-x)}$

Assume x is very small, therefore 0.60-x ≈ 0.60

$x = [OH^-] = $ 3.1937×10^{-5} M

pOH = - log (3.1937×10^{-5}) = 4.50

pH = 14 - 4.50 = 9.50
</td><td>1

1

1

1</td></tr>
<tr><td>(ii)</td><td>
Dissociation of salt: C_5H_6NCl (aq) → $C_5H_6N^+$ (aq) + Cl^- (aq)

Cl^- is anion from a strong acid, HCl. Cl^- cannot hydrolyzed in water.

The conjugate acid, $C_5H_6N^+$, is cation from a weak base, C_5H_5N, which can hydrolyze in water to form H_3O^+ @

$C_5H_6N^+$ (aq) + H_2O (l) → C_5H_5N (aq) + H_3O^+ (aq)

The presence of H_3O^+ ion makes the solution acidic. So, the pH of the salt is less than 7 and C_5H_6NCl is an acidic salt.
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1</td></tr>
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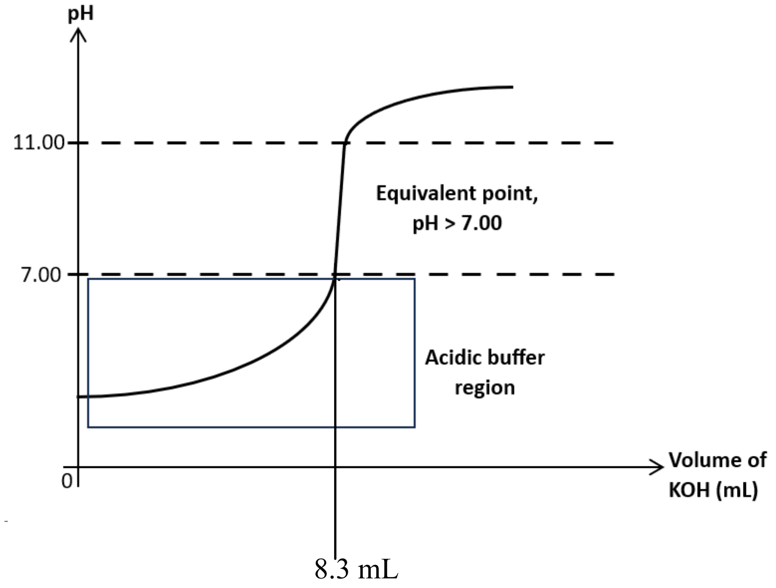
(b)		Axis + shape – 1 Equivalence point – 1 (Volume insist) Buffer region - 1
(c)	$CaF_2 (s) \rightleftharpoons Ca^{2+} (aq) + 2 F^- (aq)$ []i/M 0.5 0.1 $Q_{sp} = [Ca^{2+}][F^-]^2$ $= (0.5)(0.1)^2$ $= 5 \text{ x } 10^{-3}$ **Q_{sp} (5 x 10^{-3}) > K_{sp} (3.9 x 10^{-11})** Supersaturated solution **Solution will precipitate out until $Q_{sp}=K_{sp}$**	1 1 1
	TOTAL	**14**