<table>
<tr><th>NO</th><th>PART</th><th>SCHEME</th><th>MARKS</th><th></th></tr>
<tr><td>1</td><td>(a)(i)</td><td>Number of protons = 18-2 =16
Therefore, proton number = 16

Nucleon number = proton + neutron
= 16 + 16 = 32</td><td>1</td><td>M1</td></tr>
<tr><td></td><td>(a)(ii)</td><td>$^{32}_{16}X^{2-}$</td><td>1</td><td>M2</td></tr>
<tr><td></td><td>(b)</td><td>
$mass\ of\ C = \frac{12}{44} x\ 41.98g$
$\boldsymbol{mass\ of\ C = 11.45g}$

$mass\ of\ H = \frac{2}{18} x 6.45g$
$\boldsymbol{mass\ of\ H = 0.7167g}$

$mass\ of\ O = mass\ of\ sample - mass\ of\ C - mass\ of\ H$
$mass\ of\ O = 19.81 - 11.45 - 0.7167$
$\boldsymbol{mass\ of\ O = 7.6433g}$

<table>
<tr><th></th><th>C</th><th>H</th><th>O</th></tr>
<tr><td>mass</td><td>11.45</td><td>0.7167</td><td>7.643</td></tr>
<tr><td>mole</td><td>$= \frac{11.45}{12}$
= 0.9542</td><td>$= \frac{0.7167}{1}$
= 0.7167</td><td>$= \frac{7.6433}{16}$
= 0.4777</td></tr>
<tr><td>Mole ratio</td><td>$= \frac{0.9542}{0.4777}$
= 2 x 2
= 4</td><td>$\frac{0.7167}{0.4777}$
= 1.5 x 2
= 3</td><td>$\frac{0.4777}{0.4777}$
= 1 x 2
= 2</td></tr>
</table>

Empirical formula: $\mathbf{C_4H_3O_2}$

$mol = \frac{mass}{molar\ mass}$

$molar\ mass = \frac{mass}{mol}$

$molar\ mass = \frac{41.5\ g}{0.25} = \boldsymbol{166\ gmol^{-1}}$

$(C_4H_3O_2)n = 166$
n = 2

Molecular formula: $\mathbf{C_8H_6O_4}$
</td><td>

1

1

1

1

1

1

1</td><td>

M3

M4

M5

M6

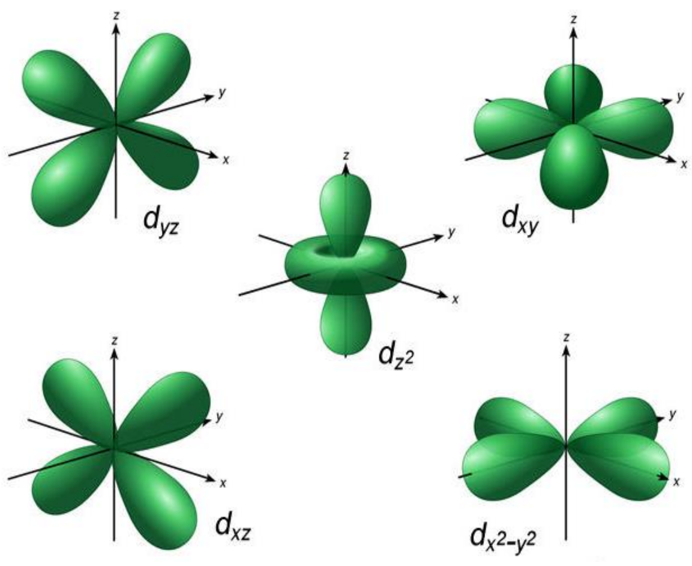
M7

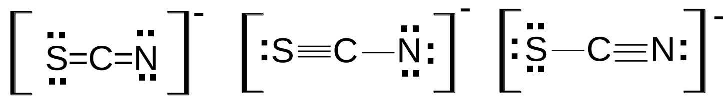
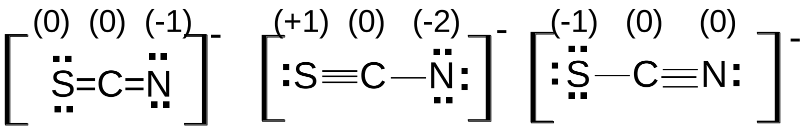
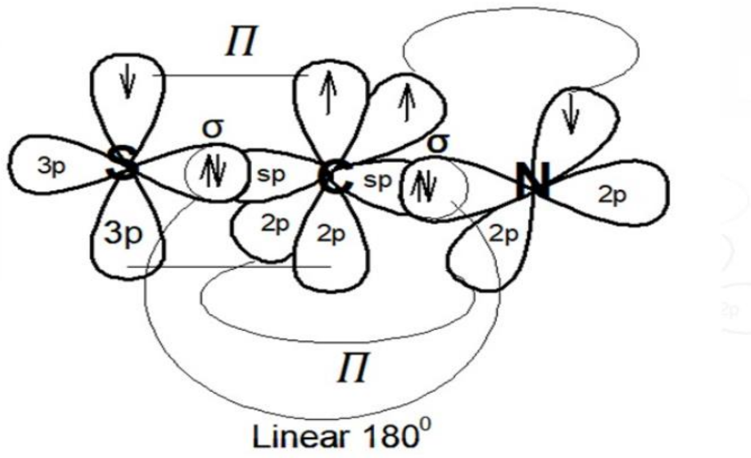
M8

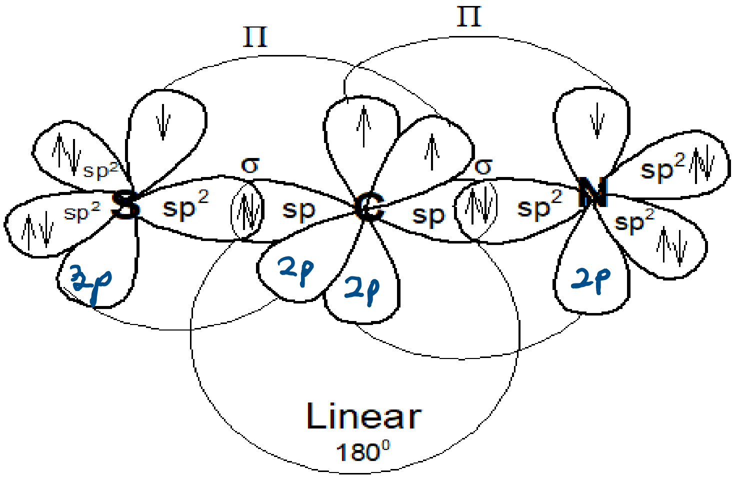
M9</td></tr>
</table>

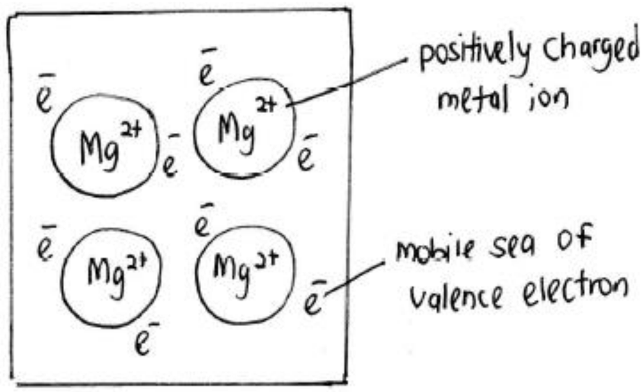
	(c)(i)	$density = \frac{mass\ of\ solution}{volume\ of\ solution}$		
		$mass\ of\ solution = density\ x\ volume\ of\ solution$ $mass\ of\ solution = 1.329\ gml^{-1} x 1000\ ml$ $\boldsymbol{mass\ of\ solution = 1329\ g}$ ……………………….	1	M10
		$\%\ w/w = \frac{mass\ of\ solute}{mass\ of\ solution}\ x\ 100$ @ $\%\ w/w = \frac{571.6\ g}{1329\ g}\ x\ 100$ ………………………………………….		
		$= \mathbf{43.01}\ \%$ ……………………………………..	1	M11
	(c)(ii)	$mol\ H_2SO_4 = \frac{571.6g}{98.1gmol^{-1}}$		
		$\boldsymbol{mol\ H_2SO_4 = 5.8267\ mol}$ …………………………..	1	M12
		Mass of solvent= mass of solution-mass of solute = 1329 - 571.6 = 757.4 g @ **= 0.7574 kg** …………………………………….	1	M13
		$\boldsymbol{Molality = \frac{mol\ of\ solute}{mass\ of\ solvent\ (kg)}}$ **@**	1	M14
		$\boldsymbol{Molality = \frac{5.827mol}{0.7574\ (kg)}}$		
		$\boldsymbol{= 7.693m\ @molkg^{-1}}$ …………………………………………..	1	M15
	(d)(i)	$\%\ yield = \frac{actual\ yield}{theoretical\ yield}\ x\ 100$	1	M16
		@ $78.1 = \frac{120\ g}{theoretical\ yield}\ x\ 100$		
		$\boldsymbol{theoretical\ yield = 153.65\ g}$ ……………………………	1	M17
		$mol\ P_4S_3 = \frac{153.65\ g}{220.3gmol^{-1}}$ = $\boldsymbol{0.6975\ mol}$ ……………………	1	M18

		$8\,mol\,P_4S_3 \equiv 3\ molS_8$ $0.6975mol\,P_4S_3 \equiv 0.6975mol\,P_4S_3 x\,\frac{3\ molS_8}{8\,mol\,P_4S_3}$ $= \mathbf{0.2616\,mol}\,S_8$ …………………………………………	1	M19
		$mass\ S_8 = 0.2616\,mol\ x\ 256.8gmol^{-1}$ $= \mathbf{67.18\ g}$ … … … … … … …. ……………………	1	M20
	(d)(ii)	$3\ mol\ S_8 \equiv 8\,mol\,P_4$ $\mathbf{0.2616\ mol}\,S_8 \equiv \mathbf{0.2616\ mol}\,S_8 x\,\frac{8\,mol\,P_4}{3\ molS_8}$ $= \mathbf{0.6976\ mol\ P_4}$ …………………………………………..	1	M21
		mol of $P_4\ left = \mathbf{1.2\ mol} - \mathbf{0.6976\ mol}$ $= \mathbf{0.5024\ mol\ P_4}$………………………………………………	1	M22
		TOTAL	**22**	
		MAX	**21**	

NO	PART	SCHEME	MARKS	
2	(a)(i)	$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$ @ $= 2.18\ x\ 10^{-18}(\frac{1}{6^2} - \frac{1}{2^2})$ $= \mathbf{-4.844\ x10^{-19}J}$ (unit insist)	**1** **1**	**M1** **M2**
	(a)(ii)	**Visible region**	**1**	**M3**
	(b)(i)	**3d** orbitals (any two answer) 	**1** **2 (shape and label)**	**M4** **M5** **M6**
	(b)(ii)	1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2	**1**	**M7**
	(c)	Expected electronic configuration: 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4 Actual electronic configuration: 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5 Half-filled 3d^5 orbital is more stable than partially orbital 3d^4	**1** **1** **1**	**M8** **M9** **M10**
		TOTAL	**10**	

NO	PART	SCHEME	MARKS	
3	(a)(i)	 Structure I Structure II Structure III	**1** **1** **1**	**M1** **M2** **M3**
	(a)(ii)	 Structure I Structure II Structure III *correct all formal charge …* **Structure I** Structure I have **lower formal** charge and the **negative charge (-1)** is at the **most electronegative atom, Nitrogen**	 **1** **1** **1**	 **M4** **M5** **M6**
	(a)(iii)	Molecular Geometry – **Linear** Bond Angle - **180^0**	**1** **1**	**M7** **M8**
	(a)(iv)	**Type of hybrid of S: sp**  **OR**	**1** **1** (Correct overlap: 2 σ bond) **1** (2 Π bond) **1** (Label sp, sp2 @ 2p for N, sp2 @ 3p for S)	**M9** **M10** **M11** **M12**

				
	(b)	The **open hexaganol structure** of the ice accounts for the fact that **ice is less dense than water due to larger volume of ice.** **OR** When ice melts, some of the **hydrogen bonds are broken**. This allows the water molecules to be **more compactly arranged, resulting in decrease in volume**. When volume decreases, density increases. Therefore, water has a higher density than ice.	**1** **1** **1** **1**	**M13** **M14**

	(c)(i)		**1** (Drawing) **1** (Label)	**M15** **M16**
	(c)(ii)	**Aluminium has 3 valence electrons, sodium has one**. The higher the number of valence electrons, the stronger the metallic bonds. @ **The size of aluminium is smaller than sodium**. The smaller the atom, the stronger the metallic bonds.	**1**	**M17**
		TOTAL	**17**	

NO	PART	SCHEME	MARKS	
4	(a) (i)	$\boldsymbol{P_T = P_{O2} + P_{H2O}}$ @ $\boldsymbol{P_{O2} = (770 - 35.5) mmHg}$	1	M1
		$\boldsymbol{= 734.5\ mmHg}$	1	M2
		$734.5 mmgHg\ x\ \frac{1\ atm}{760\ mmHg}$		
		$\boldsymbol{= 0.966\ atm}$		
	(a) (ii)	$\boldsymbol{n_{O2} = \frac{P_{O2}V}{RT}}$ @ $\boldsymbol{= \frac{0.966\ atm\ x\ 0.25\ L}{0.08206\ x\ 299.15\ K}}$	1	M3
		$\boldsymbol{= 9.84\ x\ 10^{-3}\ mol}$	1	M4
		$2KClO_3$ (s) → $2KCl$ (s) + $3O_2$ (g)	1	
		3 mol $O_2 \equiv$ 2 mol $KClO_3$	1	
		$9.84\ x\ 10^{-3} mole \equiv \boldsymbol{6.56\ x\ 10^{-3}}$ **mol $KClO_3$**	1	M5
		Mass = $6.56\ x\ 10^{-3}$ mol $KClO_3$ x (122.6 $gmol^{-1}$)		
		= 0.804g	1	M6
	(b)	Propanone has **higher** vapour pressure than propanol	1	M7
		Intermolecular forces of propanone are weaker than propanol, so easier to vapourised to form vapour	1	M8
		Propanol – **Hydrogen bond**	1	M9
		Propanone –**van der Waals forces (Dipole- dipole forces)**	1	M10
		TOTAL	**10**	
		MAX	**9**	

NO	PART	SCHEME	MARKS	
5	(a)	$[NO_2]_i = \frac{0.5\ mol}{5L} = \mathbf{0.1\ M}$		

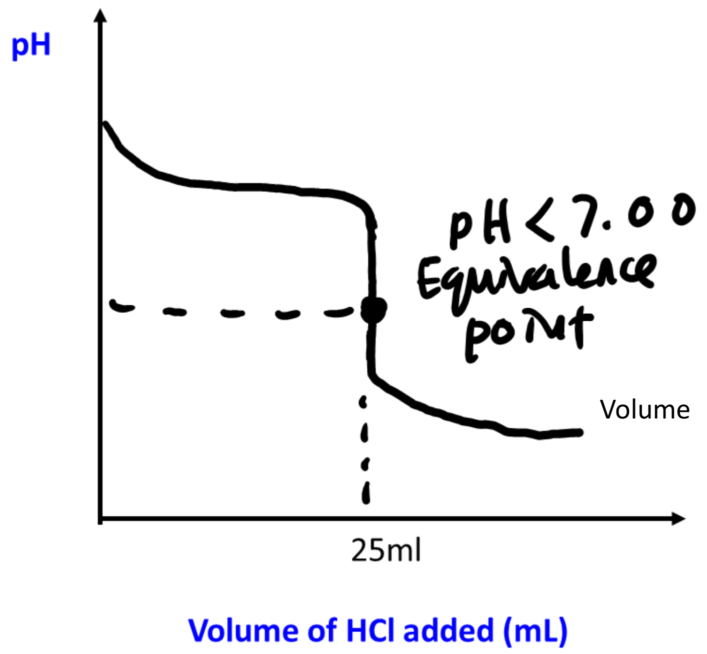
	$2NO_2\,(g) \rightleftharpoons$	$2NO\,(g)$ +	$O_2\,(g)$
Initial (M)	0.1	0	0
Change (M)	$-2x$	$+2x$	$+x$
Equilibrium (M)	$0.1-2x$	$2x$	x

NO	PART	SCHEME	MARKS	
		(table above)	1	M1
		At equilibrium; $[NO_2] = \frac{0.2\ mol}{5L} = 0.04$ M $0.1 - 2x = 0.04$ $\boldsymbol{x} =$ **0.03 M** …………………………………………	1	M2
		$K_c = \frac{[NO]^2[O_2]}{[NO_2]^2}$ @ ………………………………………………	1	M3
		$= \frac{(2\ x\ 0.03)^2(0.03)}{(0.1-2(0.03))^2}$ = **0.0675** ………………………………………………………………	1	M4
	(b)	α = $\frac{\text{[ ] change}}{\text{[ ] initial}}$ @ …………………………………………	1	M5
		= $\frac{2(0.03)}{0.1}$ = **0.6** …………………………………………	1	M6
	(c)	**Increase temperature**	1	M7
		The **forward reaction is endothermic.** By increase the temperature of the system, the equilibrium position will shift to the right to increase the yield of NO	1	M8
		Reduce pressure	1	M9
		By decrease pressure of the system, the equilibrium position will shift to the right to increase the pressure by increase the number of moles of gases and the yield of NO	1	M10
		OR		

		Remove NO or O_2 Because concentration NO or O_2 decrease, the equilibrium position will shift to favour the production of NO **OR** **Addition of NO_2** Because concentration NO_2 increase, the system will consume the added $NO_{2,}$ the equilibrium position will shift to favour the production of NO *(Choose only two)*		
		TOTAL	**10**	
		MAX	**9**	

NO	PART	SCHEME	MARKS	
6	(a)(i)	(see table below)		
		$K_b = \frac{[NH_4{}^+][OH^-]}{[NH_3]}$ @ $\mathbf{1.8\ x\ 10^{-5}} = \frac{x^2}{0.1 - x}$ @	1	M1
		Assume Kb is very small, x is very small, then 0.10-x = 0.1	1	M2
		Hence $[OH^-] = x = \mathbf{1.3416\ x\ 10^{-3} M}$	1	M3
		$\text{pOH} = -\log[\,OH^-\,]$ $\text{pOH} = -\log[\,\mathbf{1.3416\ x\ 10^{-3}}\,]$ $\text{pOH} = \mathbf{2.87}$ $\text{pH} = 14 - pOH$ $p\text{H} = 14 - 2.87$ $\mathbf{pH = 11.13}$	1	M4

	NH_3 (aq) + H_2O(l)	⇌	NH_4^+ (aq) +	OH^- (aq)
[ ]$_{Initial}$(M)	0.1	-	0	0
[ ]$_{Change}$(M)	-x	-	+x	+x
[ ]$_{Equilibrium}$(M)	**0.1-x**	**-**	**x**	**x**

	a(ii)	When addition 25 ml HCl, **equivalence point was achieves, produce salt NH_4Cl and water**. **NH_4^+ is strong conjugate acid from weak base, it will hydrolysis with water.** **$NH_4^+ (aq) + H_2O (l) \rightleftharpoons NH_3 (aq) + H_3O^+ (aq)$** The **production of H_3O^+ ions**, causes pH of the solution is less than 7. **NH_4Cl is a acidic salt.**	1 1 1	M5 M6 M7
	(a)(iii)		**1 (Shape)** **1 (eq. point <7)** **1 (label & axes)**	M8 M9 M10
(b)		$$Ba(NO_3)_2(aq) \rightarrow Ba^{2+}(aq) + 2NO_3^-(aq)$$ $[Ba^{2+}]_{new}$ $M_1V_1 = M_2V_2$ $0.025\ M x\ 20\ ml = M_2 x\ 50ml$ $\boldsymbol{M_2 = 0.01\ M}$ $$NaF(aq) \rightarrow Na^+(aq) + F^-(aq)$$ $[F^-]_{new}$ $M_1V_1 = M_2V_2$ $0.03\ Mx\ 30\ ml = M_2 x\ 50ml$ $\boldsymbol{M_2 = 0.018\ M}$	1 1	M11 M12

		$BaF_2(s) \leftrightharpoons Ba^{2+}(aq) + 2F^-(aq)$	1	M13
		$\boldsymbol{Q_{sp} = [Ba^{2+}][F^-]^2}$@ $= \mathbf{(0.01)(0.018)^2}$	1	M14
		$= \mathbf{3.24\ x10^{-6}}$ $\boldsymbol{Q_{sp} > K_{sp}}$	1	M15
		The solution is supersaturated in which the concentration of ions are too large. Thus, **precipitate. BaF_2 will form** until $Q_{sp} = K_{sp}$	1	M16
		TOTAL	**16**	
		MAX	**14**	