NJC H2 Chemistry Prelim Paper 1 Suggested Answers

1	C	**6**	B	**11**	B	**16**	C	**21**	D	**26**	D
2	D	**7**	D	**12**	D	**17**	B	**22**	B	**27**	B
3	A	**8**	D	**13**	A	**18**	A	**23**	D	**28**	A
4	C	**9**	C	**14**	C	**19**	D	**24**	C	**29**	C
5	C	**10**	A	**15**	C	**20**	B	**25**	C	**30**	C

1 Ans: **C**

SO_2 reacts with acidified $KMnO_4$
Total vol of SO_2 = 10 cm^3

Left over CO_2 reacts with NaOH(aq)
Vol of CO_2 = 2 cm^3

Vol of SO_2 produced from CS_2 = 4 cm^3
Vol of SO_2 produced from H_2S = 10 – 4 = 6 cm^3
Vol of CS_2 : Vol of H_2S = 2 : 6
mole fraction of H_2S in the mixture = $\frac{6}{8}$ = 0.750

2 Ans: **D**

Step I: Oxidation state of Cr increases from +3 in $Cr_2O_4^{2-}$ to +6 in CrO_4^{2-}.
Step II: Oxidation state of Cr remains as +6 in both CrO_4^{2-} and $Cr_2O_7^{2-}$.

$$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$$

Step III: Oxidation state of Cr decreases from +6 in $Cr_2O_7^{2-}$ to +3 in Cr_2O_3.

3 Ans: **A**

$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$
Amount of MnO_4^- required = $\frac{20}{1000}$ × 0.40 = 0.008 mol
Amount of Fe^{2+} = 5 × 0.008 = 0.040 mol

At point X, the reaction is only half completed, $[Fe^{2+}] = [Fe^{3+}]$.

E_{cell} when connected to standard hydrogen electrode = +0.77 V

The colour change at end point is from yellow to first permanent pink.

Vol $KMnO_4$ added	Species present in conical flask	Colour of solution
0	$Fe^{2+}(aq)$	Pale green
Before eqv pt	$Fe^{2+}(aq)$, $Fe^{3+}(aq)$, $Mn^{2+}(aq)$	Yellow-green
At eqv pt	$Fe^{3+}(aq)$, $Mn^{2+}(aq)$	Yellow
Just after eqv pt	$Fe^{3+}(aq)$, $Mn^{2+}(aq)$, small amt of $MnO_4^-(aq)$	Pink
In excess	$Fe^{3+}(aq)$, $Mn^{2+}(aq)$, large amt of $MnO_4^-(aq)$	Purple

4 Ans: **C**

Making reference to the I.E. values from Data Booklet, we can conclude that **I** is potassium.

Element **C** is A*l*, it is in Group 13.

Element **F** is S and it exists as S_8 molecules. The lowest boiling point is Ar gas (element **H**).

Ion of **E** (P^{3-}, 0.212 nm) is larger than that of **J** (Ca^{2+}, 0.099nm)

Element **D** and **G** are Si and C*l* respectively. The compound formed is $SiCl_4$.

5 Ans: **C**

The ionic compound can form strong ion-dipole interaction with polar solvent, making it soluble in polar solvents. The long chain hydrocarbon can also form strong temporary dipole-induced dipole interaction with non-polar organic solvents, making it soluble in organic solvents.

Around S atom, there are 4 bond pair regions and 0 lone pair, the shape is tetrahedral.

All the C atoms are sp^3 hybridised with tetrahedral shape and bond angle of 109.5°

6 Ans: **B**

pV = nRT, with n and p kept constant.
As T increases,

Option **A**: V increases. [$V = \frac{nR}{p} \times T$]

Option **B**: $\frac{pV}{T}$ remains constant. [$\frac{pV}{T} = nR$]

Option **C**: Density of the gas deceases [$\frac{m}{V} = \frac{pM_r}{RT}$]

Option **D**: pV increases. [pV = nRT]

7 Ans: **D**

$\Delta H_{rxn} = \Sigma\ \Delta H_f^{\ominus}$ (products) $- \Sigma\ \Delta H_f^{\ominus}$ (reactants)
$-27 = 3\times(-394) - [\Delta H_f^{\ominus}\ Fe_2O_3 + 3\times(-110)]$
$\Delta H_f^{\ominus}\ Fe_2O_3 = -825$ kJ mol^{-1}

8 Ans: **D**

The following processes are involved in the Born-Haber cycle for ionic compounds:

1) Enthalpy change of formation of $BaF_3(s)$
2) Enthalpy change of atomisation of Ba(s)
3) Bond energy of F−F
4) 1^{st} + 2^{nd} + 3^{rd} ionisation energies of Ba(g)
5) First electron affinity of F(g)

Ba^{3+} and F^- forms ionic compounds and would not have Ba−F bond energy.

9 Ans: **C**

Note since pressure is kept constant, ICE table **<u>should NOT</u>** be about change in pressure.

	X(g)	⇌	Y(g)	+ 2Z(g)
Initial / mol	x		0	0
Change / mol	–y		+y	+2y
Eqm / mol	x–y		y	2y

$P_Y + P_Z = p - 0.25p = 0.75p$
Since Y and Z are in a mol ratio of 1:2, $P_Y = 0.25p$, $P_Z = 0.5p$

$$K_p = \frac{(0.25p)(0.5p)^2}{0.25p} = 0.25p^2$$

10 Ans: **A**

Titration of a strong acid (H_2SO_4) with a weak base (NH_3). Equivalent point pH is less than 7 as NH_4^+ is a weakly acidic cation.

Methyl orange will be a suitable indicator as the working pH range of methyl orange coincides with the region of sharp pH change at equivalent point of this titration.

11 Ans: **B**

Since $Ca(OH)_2$ exist as aq and $Mg(OH)_2$ exist as a solid, K_{sp} of $Mg(OH)_2$ must be lower than $Ca(OH)_2$.
$|\Delta H_{hyd}| \propto$ charge density of ion, Mg^{2+} has a more exothermic ΔH_{hyd}.
$|L.E.| \propto \frac{q_+ \times q_-}{r_+ + r_-}$, magnitude of L.E. for $Mg(OH)_2$ is greater.

12 Ans: **D**

Since V_{total} is kept constant, volume of reactant used is proportional to its concentration in the final reaction mixture.
Comparing expt 3 and 4, when [P] × 2, initial rate also × 2. It is first order w.r.t **P**.
Comparing expt 4 and 2, when [R] × 2, initial rate × 4. It is second order w.r.t **R**.
Comparing expt 1 and 3, let rate = $k[P][Q]^y[R]^2$

$$\frac{\text{rate } 1}{\text{rate } 3} = \frac{k(10)(10)^y(10)^2}{k(5)(5)^y(10)^2}$$

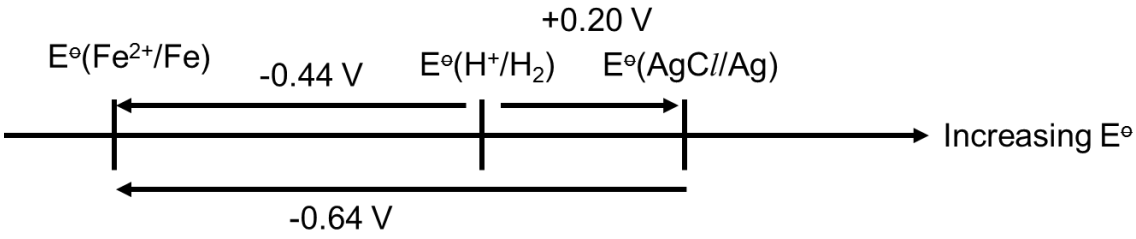
$4 = (2)(2)^y$
$(2)^y = 2$
It is first order w.r.t **Q**

13 Ans: **A**

Since $E^\ominus(MnO_4^-,H^+/Mn^{2+})$ = + 1.52 V is greater than $E^\ominus(Cu^{2+}/Cu)$ = + 0.34 V, the reduction half-cell is $MnO_4^-,H^+/Mn^{2+}$ and oxidation half-cell is Cu^{2+}/Cu.
$E^\ominus_{cell} = E^\ominus(MnO_4^-,H^+/Mn^{2+}) - E^\ominus(Cu^{2+}/Cu)$

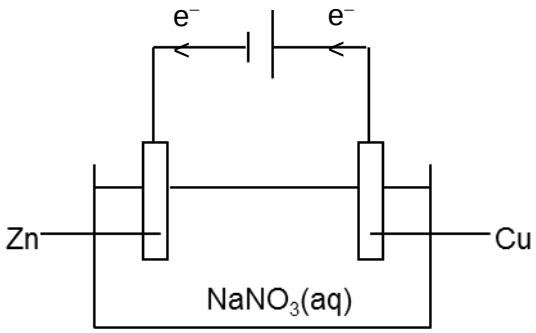
A	When excess NH_3 is added to Cu^{2+}/Cu half-cell, the half-cell become $[Cu(NH_3)_4]^{2+}/Cu$, $E^\ominus$ = –0.05 V and $E^\ominus_{cell}$ increases.
B	When additional H^+ is added into $MnO_4^-,H^+/Mn^{2+}$ half-cell, the position of equilibrium for $MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$ shifts to the right, $E^\ominus(MnO_4^-,H^+/Mn^{2+})$ increases and $E^\ominus_{cell}$ increases.
C	Size of electrode does not affect $E^\ominus(Cu^{2+}/Cu)$ as solids does not affect position of equilibrium.
D	When alloy of copper and zinc is present, Zn reacts with Cu^{2+} to give Zn^{2+} and Cu(s). The concentration of Cu^{2+} decreases and position of equilibrium for $Cu^{2+} + 2e^- \rightleftharpoons Cu$ shifts to the left, $E^\ominus(Cu^{2+}/Cu)$ decreases and $E^\ominus_{cell}$ increases.

14 Ans: **C**



15 Ans: **C**

This is the simplified electrolytic cell.



Species present: Na^+ (aq), NO_3^- (aq), H_2O, Zn cathode, Cu anode
At cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
At anode: $Cu \rightarrow Cu^{2+} + 2e^-$
The filter paper will turn blue due to the formation of Cu^{2+}(aq)
Note: this is not a litmus paper.

16 Ans: **C**

A	Melting point: $SiO_2 > Na_2O > P_4O_{10}$ SiO_2 (covalent lattice with strong covalent bond) Na_2O (ionic lattice with strong ionic bond) P_4O_{10} (simple molecular with weak IMF)
B	Covalent character: $P_4O_{10} = SiO_2 > Na_2O$
C	pH when mixed with water: Na_2O (pH = 14) > SiO_2 (pH = 7) > P_4O_{10} (pH = 3)
D	Na_2O is soluble in aq alkali due to reaction of Na_2O with H_2O to give NaOH. SiO_2 is insoluble in aq alkali due to strong covalent bond in the covalent lattice. P_4O_{10} is soluble in aq alkali due to reaction of P_4O_{10} with NaOH to give Na_3PO_4.

17 Ans: **B**

$M(NO_3)_2(s) \rightarrow MO(s) + 2NO_2(g) + ½\ O_2(g)$ (option 2 is correct)

Ionic radius of Mg^{2+} is smaller than Ba^{2+}. Mg^{2+} has a higher charge density and stronger polarising power. Mg^{2+} is able to distort electron cloud of NO_3^- to a larger extent and N–O covalent bond in $Mg(NO_3)_2$ is weakened significantly. Hence $Mg(NO_3)_2$ decompose at a lower temperature. (option 1 is correct).

|L.E.| $\propto \frac{q_+ \times q_-}{r_+ + r_-}$, magnitude of L.E. for $Mg(NO_3)_2$ is greater. However, N–O covalent bond is broken during thermal decomposition and hence we should not even be comparing the lattice energy.

18 Ans: **A**

Before heating, YCl_n reacts with $AgNO_3$ to produce 8.368×10^{-3} mol of $AgCl$.
After heating, the product reacts with $AgNO_3$ to produce 5.021×10^{-3} mol of $AgCl$.

This shows that Y can form two chlorides with different oxidation state.
Y must be from Group 15 (e.g. PCl_5 and PCl_3)

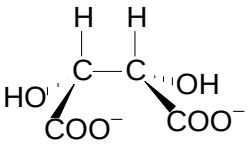
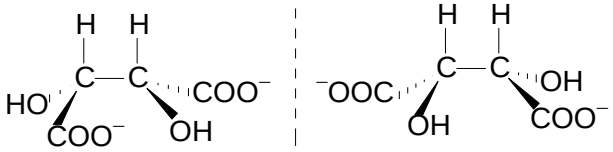
1 mol of YCl_5 gives 5 mol of Cl^-
Amount of $YCl_5 = (8.368 \times 10^{-3}) \div 5 = 1.674 \times 10^{-3}$ mol
M_r of $YCl_5 = 0.50 \div 1.674 \times 10^{-3} = 298.8$
A_r of $Y = 298.8 - 5 \times 35.5 = 121.3$
Y is Sb

19 Ans: **D**

Down Group 17,

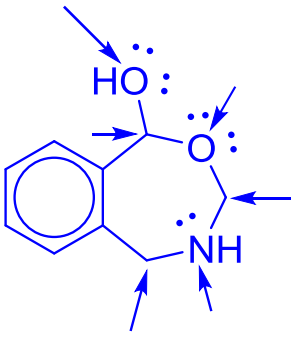
- Thermal stability of HX decreases due to weaker bond energy
- Enthalpy change of formation becomes less exothermic (calculate using BE values)
- The ease of oxidation increases as $E^{\ominus}(X_2/X^-)$ decreases down the group.

20 Ans: **B**

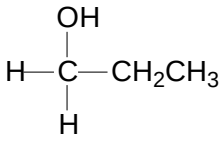
A	The tartrate ion acts as a Bronsted acid, it donates 2 H^+ to react with 2 OH^- and form the new ligand.
B	There are 2 chiral carbons for tartrate ion with 4 possible stereoisomers. However due to internal line of symmetry, 2 of the isomers are identical (they are known as the meso compound). Hence there are only 3 stereoisomers.  
C	The coordination number of the complex ion is 4. (4 dative bonds)
D	The oxidation number of Cu in the complex ion is +2. The ligands each have a charge of –3 after losing a H^+ from the tartrate ion.

21 Ans: **D**

There are a total of 6 central atoms with tetrahedral electron geometry. Hence, these 6 atoms are sp^3 hybridised. Take note that for the case of O and N in the molecule, the lone pair sits in the sp^3 orbital.



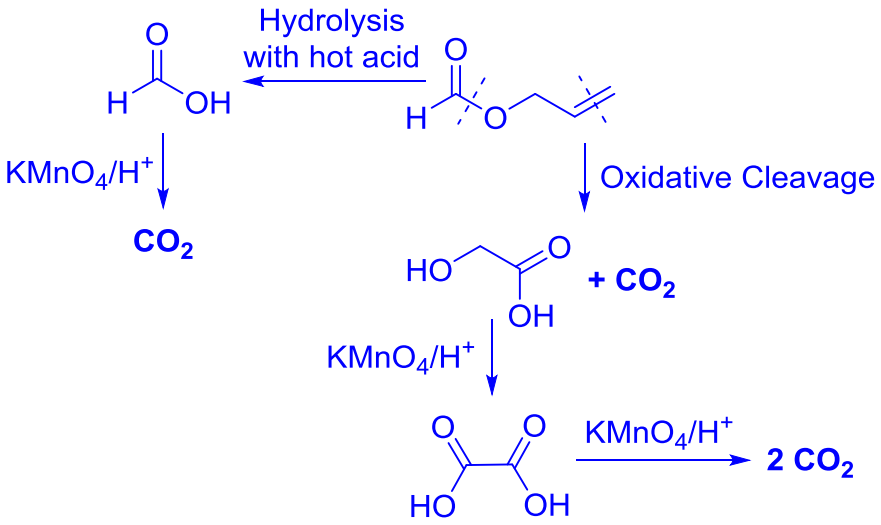
22 Ans: **B**



is the minor product from the addition reaction due to the lower stability of the carbocation intermediate.

23 Ans: **D**

4 moles of CO_2 can be obtained from the reaction of compound **A** with hot excess acidified $KMnO_4$.



Since 1 mole of $CaCO_3$ can be obtained from every mole of CO_2 produced,
Mass of $CaCO_3$ = 4 x 100.1 = **400.4** g

24 Ans: **C**

The molecular formula is $C_8H_9NO_5$. **(option 1 is wrong)**

There are 2 chiral carbons with 1 C=C bond capable of cis-trans isomerism. Hence total number of stereoisomer = 2^3 **(option 2 is correct)**

HBr(g) reacts with alkene and alcohol groups, 2 Br atoms are found in the product. **(option 3 is correct)**

Li*Al*H_4 reduces carboxylic acid and amide but not alkene. Only 4 H atoms are found in the product. **(option 4 is wrong)**

25 Ans: **C**

The energy profile diagram suggests the substitution proceeds in 2 steps, meaning it is an S_N1 reaction. This would mean that the rate = k $[(CH_3)_3CCl]$. Overall order of reaction would be 1 (**option 2 is correct**). $[OH^-]$ would not affect the rate of reaction (**option 4 is wrong**).Intermediate Z is the carbocation (**option 1 is wrong**).

Rate of reaction is also not based on products. There is also no equilibrium established in this question. Le Chatelier's Principle does not apply in this question. Removal of product does not cause any increase in the yield (**Option 3 is correct**).

26 Ans: **D**

$NaBH_4$ only reacts with carbonyl groups. $H_2(g)$, Ni(s) can react with alkene, carbonyl and nitrile group.

27 Ans: **B**

Acyl chloride reacts readily with water to give Cl^-.
Alkyl halide reacts with hot $OH^-(aq)$ to give Cl^-.
C–C*l* bond in chlorobenzene and C*l* bonded directly to C=C has a partial double bond character due to delocalisation of lone pair electron of C*l* into the neighbouring π electron cloud. These C–C*l* bond will not break upon heating with $OH^-(aq)$

28 Ans: **A**

–OH in phenol is 2, 4 directing w.r.t the –OH group, dilute HNO_3 will only lead to mono nitration.

29 Ans: **C**

The cyanohydrin product from propanone does not contain a chiral centre, only one product $CH_3C(OH)(CN)CH_3$ is formed. Hence it cannot be considered as racemic mixture

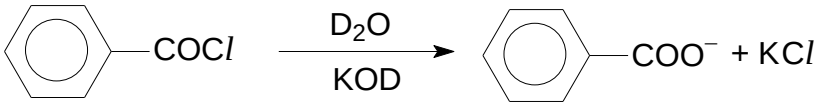
δ+ C atom in propanal experiences less steric hindrance and is able to react with the nucleophile CN^- at a faster rate. Furthermore, there are 2 electron donating alkyl groups bonded directly to the δ+ C atom in propanone, decreasing the magnitude of δ+ on the C atom. Hence propanone reacts with the nucleophile CN^- at a slower rate.

The cyanohydrin product $CH_3C(OH)(CN)CH_3$ reacts with hot NaOH(aq) to give pungent NH_3 gas which turns moist red litmus paper blue.

30 Ans: **C**

A $CH_3CH_2CN \xrightarrow[DCl,\ heat]{D_2O} CH_3CH_2COOD + NH_4^+$

B $CH_3COCHI_2 \xrightarrow[D_2O,\ warm]{I_2,\ NaOD} CH_3COO^- + CDI_3$

C 

D $CH_3CH_2CONHCH_3 \xrightarrow{LiAlD_4} CH_3CH_2CD_2NHCH_3 + D_2O$