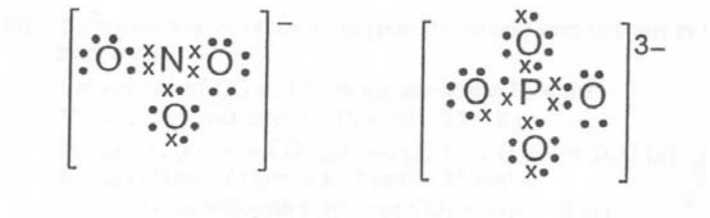
Pioneer Junior College
JC2 Preliminary Examination 2008
H2 Chemistry Paper 2
Suggested Answers

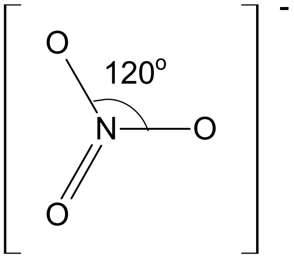
1 **(a)** **(i)** Both N_2 and P_4 have simple molecular structure. They are non polar molecules, held together by weak van der waals forces due to induced dipole – induced dipole attractions.

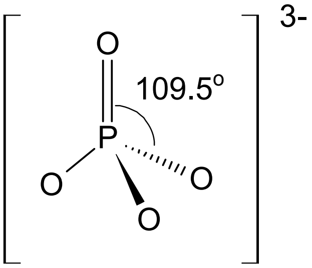
As P_4 has a greater number of electrons / larger electron cloud to be polarised leading to stronger van der waals forces between P_4 molecules. This results in higher melting point in P_4, hence P_4 exists as solid.

(ii) Phosphorus is a relatively big atom with diffused orbitals, side-on overlap of its p orbitals to form π bonds is much less effective than head-on overlap to form sigma bond.

(b) **(i)**







Shape of NO_3^- is trigonal planar.
Shape of PO_4^{3-} is tetrahedral.

(ii) To form NO_4^{3-}, N must be able to accommodate 10 electrons in its valence shell. Since N is in Period 2, it has no energetically accessible/low lying d orbitals to expand its octet.

2 **(a)** $SrF_2(s) + aq \rightleftharpoons Sr^{2+}(aq) + 2F^-(aq)$

Solubility of strontium fluoride = 0.073 / 125.6
= 5.81×10^{-4} mol dm^{-3}

$K_{sp} = [Sr^{2+}]_{eqm}[F^-]_{eqm}{}^2$
$= (5.81 \times 10^{-4})\,(2 \times 5.81 \times 10^{-4})^2$
$= 7.85 \times 10^{-10}\ mol^3\ dm^{-9}$

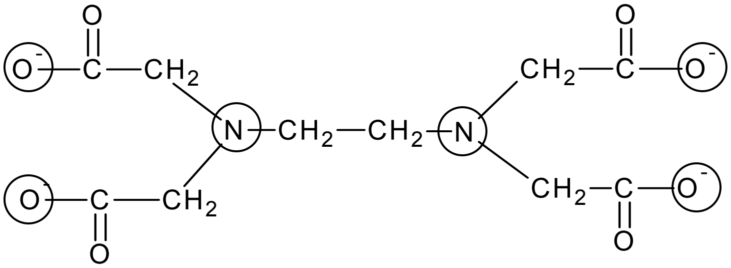
(b) $[Sr^{2+}] = (0.0100 \times 25.0/1000) \div (45.0/1000) = 0.00556\ mol\ dm^{-3}$

$[F^-] = (0.0150 \times 20.0/1000) \div (45.0/1000) = 0.00667\ mol\ dm^{-3}$

Ionic product of $SrF_2 = (0.00556)\,(0.00667)^2 = 2.47 \times 10^{-7}\ mol^3\ dm^{-9}$

Since ionic product is greater than solubility product, precipitate of SrF_2 will form.

3 (a)



edta

(b) (i) On dropwise addition of $NH_3(aq)$, blue precipitate of $Cu(OH)_2(s)$ is observed.

Equilibrium (1):

$Cu^{2+}(aq) + 2OH^-(aq) \rightleftharpoons Cu(OH)_2(s)$

On adding excess $NH_3(aq)$, blue precipitate dissolves to give a deep blue solution due to formation of $[Cu(NH_3)_4(H_2O)_2]^{2+}$ complex. **[**

Equilibrium (2):

$Cu(OH)_2(s) + 4NH_3(aq) + 2H_2O \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+} + 2OH^-(aq)$

By forming the complex, $\underline{[Cu^{2+}(aq)]\ \text{decreases}}$, leading to decrease in ionic product of $Cu(OH)_2$ to the extent of $\underline{\text{ionic product} < K_{sp}}$. ∴ Precipitate dissolves.

Or

Equilibrium (2):
$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$

By forming the complex, $\underline{[Cu^{2+}(aq)]\text{ decreases}}$, position of equilibrium (1) shifts to the left according to Le Chatelier's Principle, ∴ precipitate dissolves.

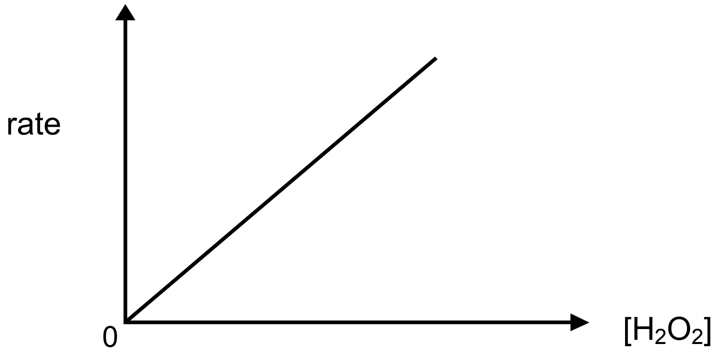
(ii) Type of reaction: Ligand exchange
$[Cu(NH_3)_4(H_2O)_2]^{2+} + edta^{4-} \rightarrow [Cu(edta)]^{2-} + 4NH_3 + 2H_2O$

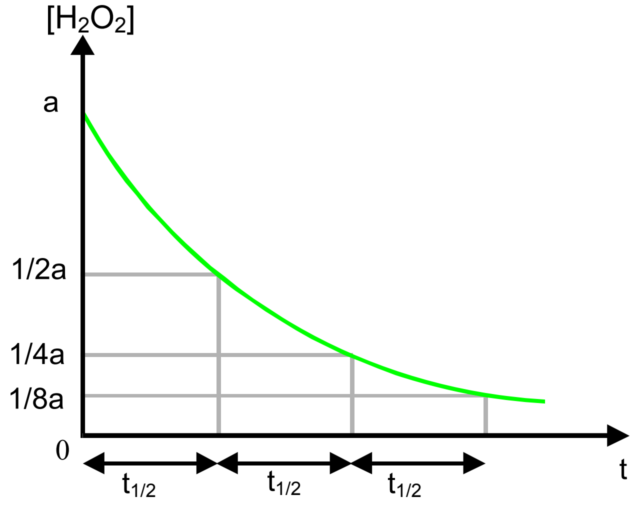
(c) (i) Due to high K_c (position of equilibrium lies more to the right), the poisonous Cd^{2+} can be removed by solution of edta through complex formation.

(ii) Due to relatively similar K_c values, Zn^{2+} will be removed in addition to Cd^{2+}. This is not desirable as zinc is essential for health.

4 (a) (i) rate = $k[H_2O_2]$

(ii)

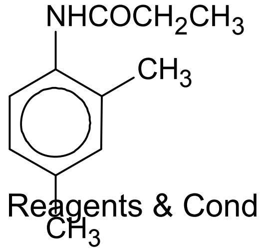




(b) **(i)** Co(II) acts as homogeneous catalyst due to its ability to exhibit variable oxidation states.

(ii) Tartaric acid functions as a ligand (or a complexing agent) to complex with Co(III), thus stabilising it.

5 **(a)** **(i)**



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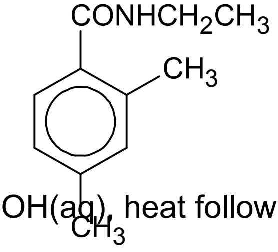
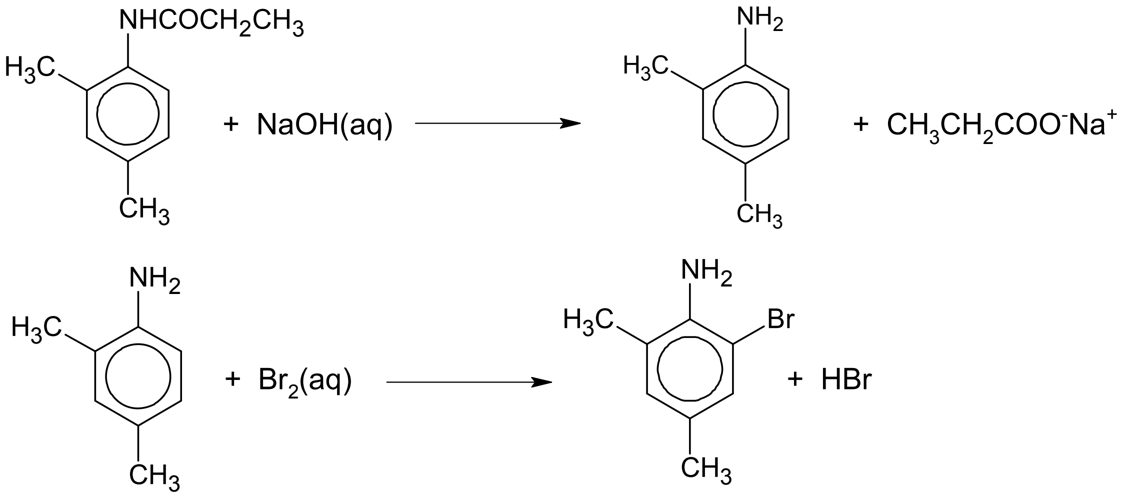


Reagents & Conditions: NaOH(aq), heat followed by Br_2 (aq) after cooling

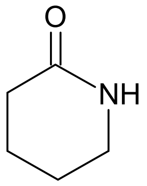
A **B**

To each compound in separate test tubes, add NaOH(aq) and heat. Add Br_2(aq) after cooling the mixture.

The test-tube containing **A** will decolourise reddish brown aqueous bromine with the formation of a white precipitate. Reddish brown aqueous bromine remains for test tube containing **B**.



(b)



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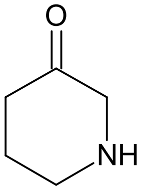
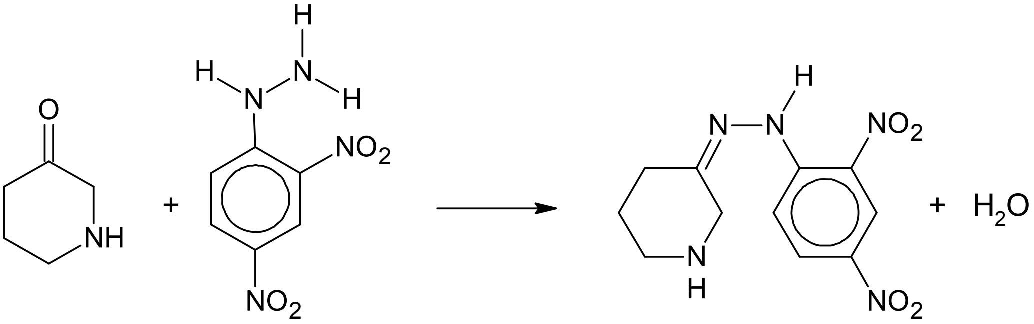


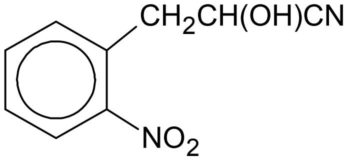
C **D**

To each compound in separate test tubes, add 2,4-dinitrophenylhydrazine.

An orange precipitate will form in test-tube containing **D** and no precipitate observed for test-tube containing **C**.



6 **(a)** **(i)**



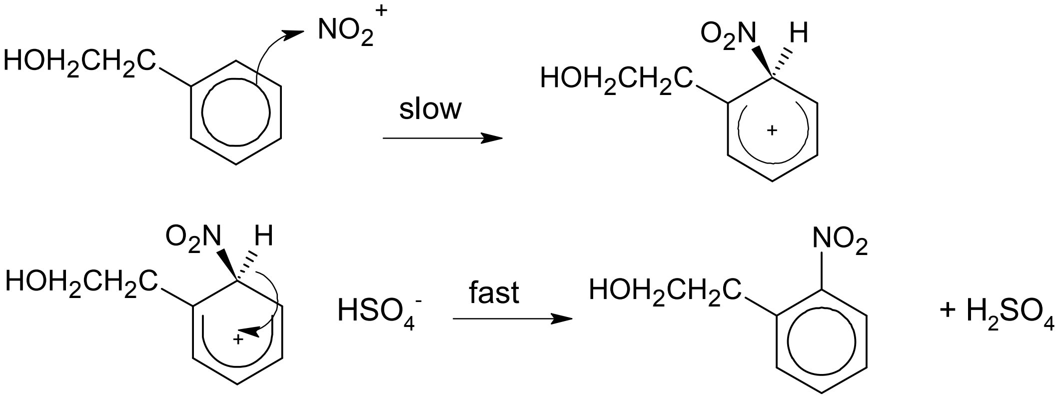
A

(ii) **Step 1:** concentrated HNO_3, concentrated H_2SO_4, 30°C
Step 2: $K_2Cr_2O_7$, H_2SO_4(aq), distil
Step 3: HCN, trace amount of NaOH or NaCN, 10 – 20°C
Step 4: HC*l*(aq),heat

(b) **Step 3:** nucleophilic addition
Step 4: acid hydrolysis

(c) Electrophilic substitution

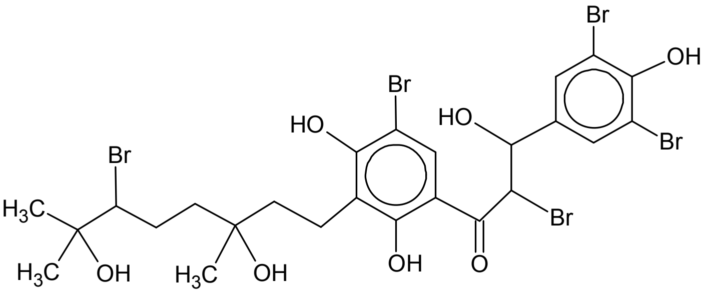
$$HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + 2HSO_4^- + H_3O^+$$



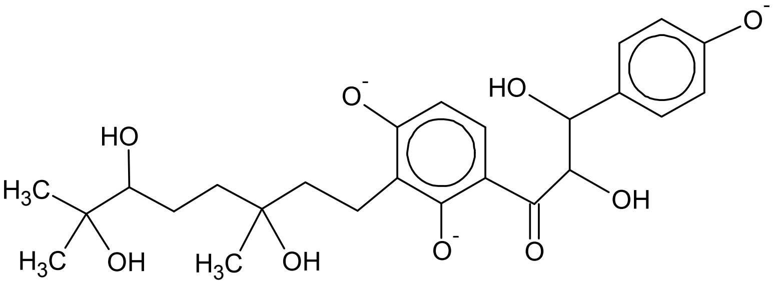
[½] for equation for generation of catalyst

7 (a) Alkene, 3° alcohol, phenol and ketone

(b) (i) Reddish brown aqueous bromine decolourises with the formation of a white precipitate.



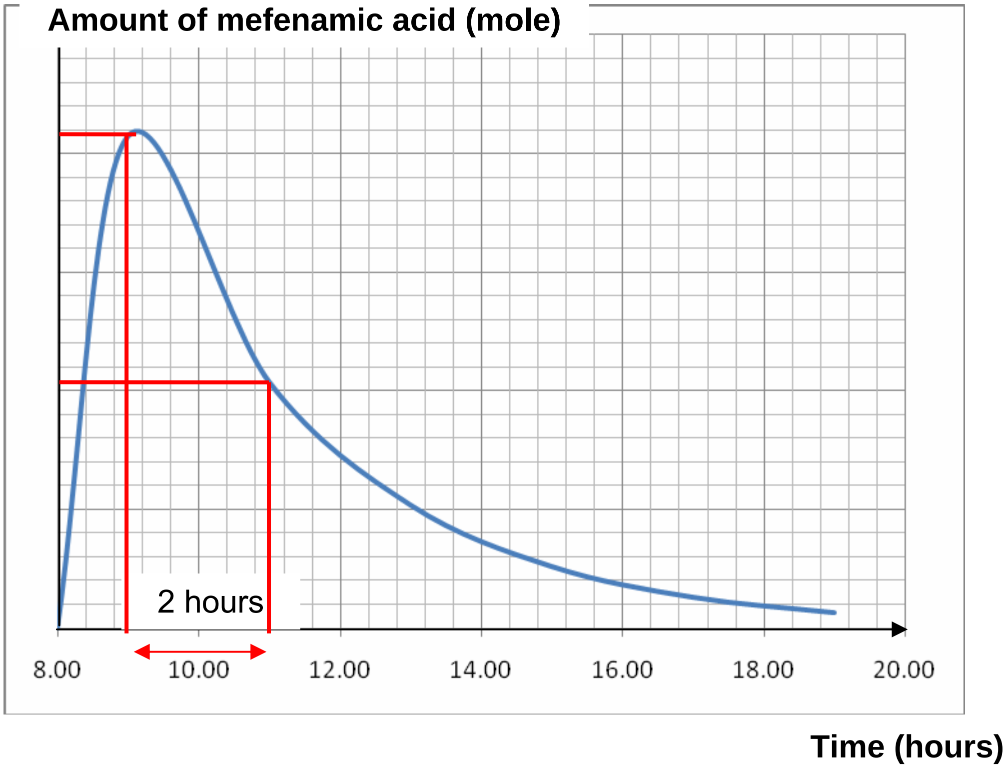
(ii) Purple $KMnO_4$ turns green (MnO_4^{2-}) and a brown precipitate of MnO_2 is obtained eventually.



8 (a) Molar mass of $C_{15}H_{15}NO_2$
$= (12.0 \times 15) + (1.0 \times 15) + 14.0 + (16.0 \times 2) = 241 \text{ g mol}^{-1}$

Amount of $C_{15}H_{15}NO_2$ in 2 capsules
$= (50 \times 10^{-3} \times 2) / 241 = 0.000415$ mol

(b)



Half-life ≈ 2 hours

(c) **(i)** Solubility of mefenamic acid $= (20 \times 10^{-3}) / 241$
$= 8.30 \times 10^{-5}$ mol dm^{-3}

(ii) Although mefenamic acid contains carboxylic acid group and amine group that are capable of forming hydrogen bonds with water molecules, the presence of the two large hydrophobic aromatic rings results in its low solubility in water.

(d) NaOH(aq) / Na_2CO_3(aq) at room temperature

(e) Overdose = 740 mg kg^{-1}

Mass of mefenamic acid that result in an overdose in a 65 kg patient
$= 740 \times 65 = 48100$ mg $= 48.1$ g

Since the bioavailability of mefenamic acid is given to be 90%,
maximum mass of mefenamic acid that can be ingested before an "overdose" occurs = 48.1 / 0.9 = 53.4 g