2021-2022 S.6 Chemistry Mock Exam
Paper 2 (Marking Scheme)

Section A Industrial Chemistry

1. (a) (i) The reaction is exothermic, meaning that percentage yield increases as temperature decreases. [1]

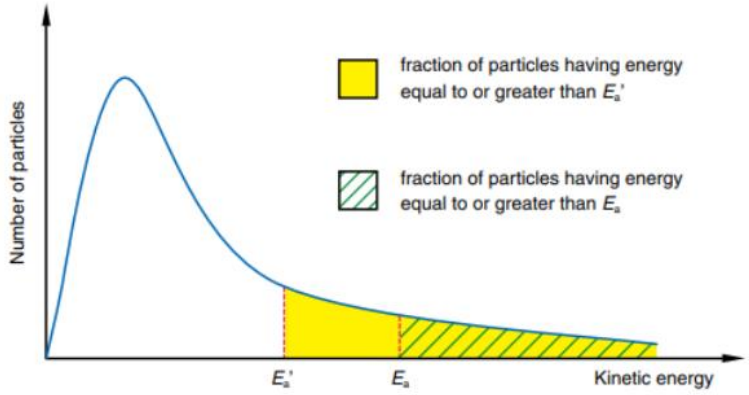
However, the rate of reaction is low at low temperatures. So, a compromise temperature of 450 °C is chosen. [1]

Common mistake:
- Justified the chosen temperature in terms of construction and maintenance cost, instead of percentage yield and rate of reaction

(ii) The product mixture is cooled to remove ammonia. [1]
The unreacted N_2 and H_2 gases are recycled for further reaction. [1]

Common mistakes:
- Related the recycle of unreacted reactants to energy conservation (i.e. to preheat feedstock) or rate of reaction, instead of increasing percentage of conversion
- Suggested a continuous supply of reactants instead of recycling the unreacted reactants
- Suggested changing the reaction conditions such as increasing the temperature and pressure, not knowing that the conditions are already optimised.
- Suggested the use of catalyst, not knowing that the use of catalyst does not affect the equilibrium position and percentage yield

(iii) 1 mark for diagram [1]



In the diagram, E_a represents the activation energy of the uncatalyzed pathway. Iron provides an alternate pathway of lower activation energy, E_a'. [1]

Thus, more particles have kinetic energy greater than or equal to activation energy to react / more particles have sufficient energy to react. [1]

The number of effective collisions per unit time/ frequency of effective collision increases. [1]

Common mistakes:
- Wrongly added an extra curve to show the distribution at a higher temperature, instead of marking a lower activation energy on the x-axis.
- The distribution curve was not started from zero.
- Labelled the y-axis as 'kinetic energy' instead of 'number of particle'

(b) (i) A.E. = $\frac{6}{34} \times 100\% = 17.6\%$ [1]

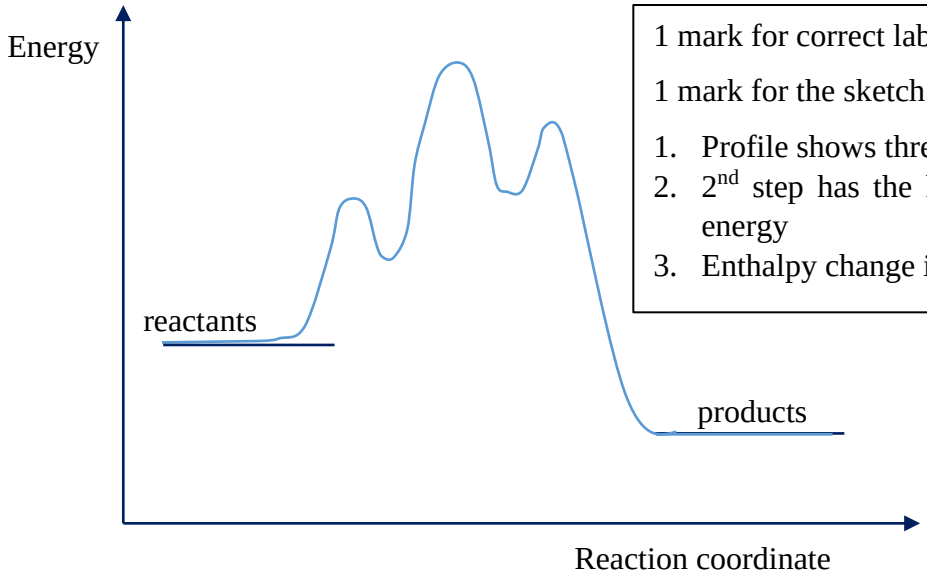
(ii) (1) The atom economy of the reaction is 100%. /
The reaction involved the use of catalyst ($Cu/ZnO/Al_2O_3$). [1]
[Not accept: 'The reaction consumes CO(g) which is an air pollutant.']

Remark:
- As the atom economy is 100%, should not just say that the atom economy is high.

(2) The reaction involves the use of toxic carbon monoxide. / A high pressure is required for the reaction. (Accept other reasonable answers) [1]
[Not accept: 'Methanol is toxic.']

Remark:
- It is better to give the specific hazard nature of CO, which is toxic, instead of just state that it is hazardous or harmful.

(c) (i)



1 mark for correct labels of 2 axes. [1]

1 mark for the sketch with: [1]

1. Profile shows three steps
2. 2nd step has the highest activation energy
3. Enthalpy change is negative

Common mistake:
- Profile showing 2 steps instead of 3.

Remark:
- Should give the labels 'reactants' and 'products'

(c) (ii) (1) $2\ Cl^- \rightarrow Cl_2 + 2e^-$ [1]

(2) Na^+ ions are discharged at the mercury electrode/ cathode forming Na (Na/Hg) / amalgamated Na. [1]

The sodium amalgam / amalgamated sodium / Na / (Na/Hg) is then mixed / reacted with water in a tank to form NaOH(aq) and $H_2(g)$. [1]

Common mistake:
- Stated that H^+ ions, instead of Na^+ ions, are discharged

1. (c) (iii) (1) Order of reaction = slope of time = 2/4 = 0.5 or ½ [1]

Common mistakes:
- Wrong calculation of the slope
- Wrongly thought that the order of reaction is 1 because the graph shows a straight line.

(2) From the graph, at 100 °C, y-intercept = -2,
log k = -2
$k = 10^{-2}\ mol^{1/2}\ dm^{-3/2}\ s^{-1}$. [1]

Common mistakes:
- Gave answer without a unit or with a wrong unit
- Did not know that the y-intercept in the graph equals to log k

(3) $log 16r_o - log r_o = -\frac{E_a}{2.3 \times 8.31}(\frac{1}{423} - \frac{1}{373})$ [1]

E_a = 72600 J mol^{-1} (72.6 kJ mol^{-1}) [1]

Common mistake:
- Gave kJ as the unit instead of kJ mol^{-1}

Section B Analytical Chemistry

2. (a) (i) Add acidified silver nitrate solution. [1]

Yellow precipitate formed. [1]

Common mistakes:
- Did not acidify the silver nitrate solution added
- Wrongly suggested the use of an O.A. to oxidize I^- ions, not knowing that it only shows I^- ions as a R.A. but not identifying the presence of I^- ions.

(ii) A greenish/ greenish yellow gas evolved. [1]

$ClO^-(aq) + Cl^-(aq) + 2H^+(aq) \rightarrow Cl_2(g) + H_2O(l)$ [1]

Common mistake:
- Failed to balance the chemical equation correctly

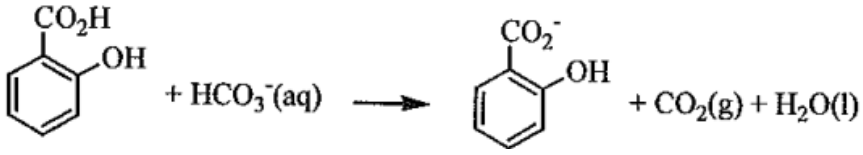
(iii) Colorimetry / Infra-red spectroscopy [1]

Common mistake:
- Suggested a chemical method instead of an instrumental method

(b) (i) To convert 2-hydroxybenzoic acid to the carboxylate salt which is soluble in water. [1]

Common mistake:
- Failed to describe the reaction between 2-hydroxybenzoic acid and $NaHCO_3(aq)$ and stated that the '2-hydroxybenzoic acid dissolves in $NaHCO_3(aq)$'

(ii)



[1]

2-hydroxybenzoic acid reacted with $NaHCO_3(aq)$ to produce carbon dioxide. Pressure built up inside the separating funnel. [1]

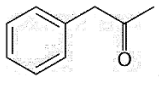
Common mistake:
- Incomplete explanation: either did not specify the gas formed or did not mention the consequence of gas formation

(c) (i) The IR spectrum shows a peak at 1680 – 1800 cm^{-1} corresponds to a C=O group. [1]

A negative result in Tollens' reagent test shows that **X** is not an aldehyde. [1]

The peak at m/z = 43 corresponds to CH_3CO^+. [1]

The peak at m/z = 91 corresponds to $C_6H_5CH_2^+$. [1]

Structure of compound **X** is $C_6H_5CH_2COCH_3$ /  . [1]

Common mistakes:

- Missed the '+' sign for the species that gave the peak in mass spectrum, that is, not knowing that the species must be ions.
- Some did not use the information from the mass spectrum to work out the structure of compound X

(ii) Mass spectrum of **Y** has peak at m/z = 29 ($CH_3CH_2^+$) / 77 ($C_6H_5^+$) / 105 ($C_6H_5CO^+$) which is not present in the mass spectrum of **X**. [1]

[Also accept: Mass spectrum of Y does not have the peak at m/z = 91.]

Common mistakes:

- Wrongly thought that Y has C=O group at C1 and thus gave a peak at m/z = 29 corresponding to CHO^+. Failed to recognise that if the C=O group is at C1 in Y, then Y and X will be functional group isomers instead of position isomers.
- Failed to give answer in a comparative manner
- Did not mention or failed to identify the correct corresponding ions for the peak mentioned

(iii) Yellow / orange / red precipitate was formed. [1]

Common mistake:

- Wrongly stated that 'the solution changed to yellow/orange colour' and not realizing that precipitates are formed.

(d) (i) (1) $2\ Cu^{2+}(aq) + 4\ I^-(aq) \rightarrow 2\ CuI(s) + I_2(aq)$ [1]

(2) $I_2(aq) + 2\ S_2O_3^{2-}(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq)$ [1]

Common mistakes:

- For (1), wrote an equation with Cu, instead of CuI, as the product formed
- The equations were not balanced

(ii) Mole ratio of $Cu^{2+}(aq) : S_2O_3^{2-}(aq) = 1 : 1$ [1]

Mass of $Cu^{2+}(aq)$ in the sample:

$= 27.80 \times 10^{-3} \times 0.103 \times 10 \times 63.5$ [1M]

$= 1.818$ g

% by mass of Cu in the ore

$= 1.818 / 4$

= 45.46% (also accept 45.45% or 45.5%) [1]

Common mistake:

- Failed to give the correct mole ratio for $Cu^{2+}(aq) : S_2O_3^{2-}(aq)$ as their answers in (i) were incorrect.