遵理學校
Beacon College
課程查詢熱線: 2474 4267(新界區)
2374 4099(九龍區)
2834 1833(港島區)
http://www.beacon.com.hk
e-mail:beacon@beacon.com.hk

2010-2011

Advanced Level Mock Examination

Chemistry- Paper I

Marking Scheme

Dr. Kelvin Lau

Marks

1. (a) (i) Standard enthalpy change of Reaction path (I)

= (416 + 193) – (276 + 364) 1

= -31 $kJmol^{-1}$ 0.5

(ii) Bond enthalpy is the average value of bond dissociation enthalpies. 1

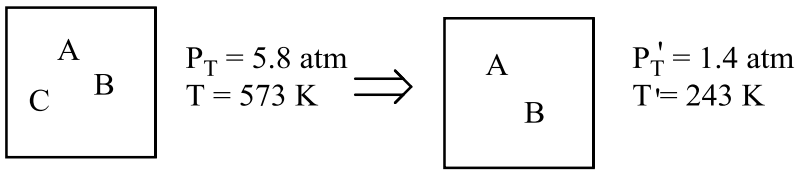
The experimental data of Reaction path (I) is expected to be more positive. 0.5

Since bromine atom is large in size. 0.5

The steric hindrance of the Reaction path (I) is larger. 0.5

More energy is required to overcome the repulsion between the Br and CH_3 group. (Activation energy is higher) 1

(b) (i)



$P_{(A+B)}V = n_{(A+B)}RT$ $\qquad$ $P_T'V = n_{(A+B)}RT'$ 0.5

$\Downarrow$

$(P_T\ \chi_{(A+B)})\,V = n_{(A+B)}RT$

$$\frac{(P_T\ \chi_{A+B})V}{P_T'V} = \frac{n_{(A+B)}RT}{n_{(A+B)}RT'}$$

$$\frac{(P_T\ \chi_{A+B})}{P_T'} = \frac{T}{T'}$$

$$\chi_{(A+B)} = \frac{T\ P_T'}{T'\ P_T} = \frac{(573)(1.4)}{(243)(5.8)} = 0.5692$$ 1

Let $\chi_A = y$ and $\chi_B = 2y$

$3y = 0.5692 \qquad y = 0.1897$

Therefore, $\chi_A = 0.1897$ 0.5

$\chi_B = 0.3795$ 0.5

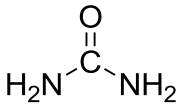
$\chi_C = 1 - 0.1897 - 0.3795 = 0.2411$ 0.5

(ii) Assumption: All gases are ideal gases 1

				Marks
2.	(a)	(i)	$Ba^{+}(g) \rightarrow Ba^{2+}(g) + e^{-}$	0.5
			[Award 0 mark for wrong physical state]	
		(ii)	$3\ Mg^{2+}(g) + 2\ N^{3-}(g) \rightarrow Mg_2N_3(s)$	0.5
			[Award 0 mark for wrong physical state]	
		(iii)	$H(g) + e^{-} \rightarrow H^{-}(g)$	0.5
			[Award 0 mark for wrong physical state]	
		(iv)	$C_8H_{18}O(l) + 12\ O_2(g) \rightarrow 8\ CO_2(g) + 9\ H_2O(l)$	0.5
			[Award 0 mark for wrong physical state]	
	(b)	(i)	$2\ OH^{-}(aq) + 2\ F_2\ (g) \rightarrow OF_2\ (aq) + 2\ F^{-}(aq) + H_2O(l)$	1
			Yellow gas dissolves to give a colorless solution.	1
		(ii)	$2OCl^{-}\ (aq) \rightarrow 2\ Cl^{-}\ (aq) + O_2\ (g)$	1
			Colorless gas evolves.	1
		(iii)	$Na_2CoCl_4(s) + 6\ H_2O \rightarrow Co(H_2O)_6^{2+}(aq) + 4\ Cl^{-}(aq) + 2\ Na^{+}(aq)$	1
			The blue solid dissolves to give a pink solution.	1
2	(c)	(i)	Na+: face-centered cubic structure	0.5
			Cl-: face-centered cubic structure	0.5
		(ii)	Number of ions of Na^{+} in one unit cell = 4	0.5
			Number of ions of Cl^{-} in one unit cell = 4	0.5
			Mass of one unit cell = $\frac{4\times 23.0 + 4\times 35.5}{6.02\times 10^{23}} = 3.887 \times 10^{-22}$	0.5
			Volume of unit cell = $\frac{3.887\times 10^{-22}}{2.165} = 1.795 \times 10^{-22}\ cm^3$	0.5 1
			Edge of the unit cell = $\sqrt[3]{1.795\times 10^{-22}} = 5.64 \times 10^{-8} cm$	

Marks

3. (a)



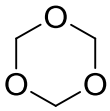
1

Catalyst: concentrated sulphuric acid. 1

(b) There are no alkyl groups attaching to the carbonyl carbon of formaldehyde. Thus, the absence of positive effect leads to the high partial positive charge density of the carbonyl carbon in the molecule. 0.5

The carbonyl carbon of formaldehyde is not sterically hindered. It is easily attacked by nucleophile. 0.5

(c)

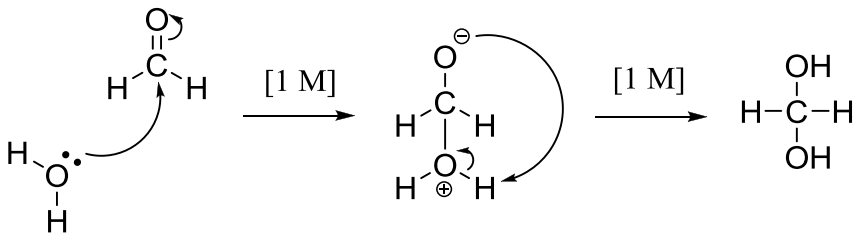


1

Hybridization state of C = sp^3 0.5

Hybridization state of O = sp^3 0.5

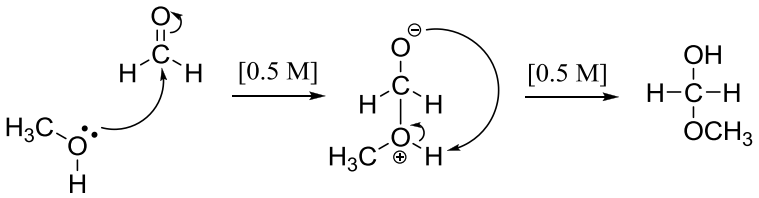
(d)



2

Marks

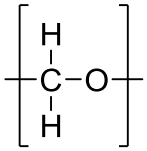
3. (e)



1

Methanol reversibly reacts with formaldehyde. This can <u>suppress the formation of the diol.</u> Thus the oxidation diol for formic acid can be controlled. 1

(f)



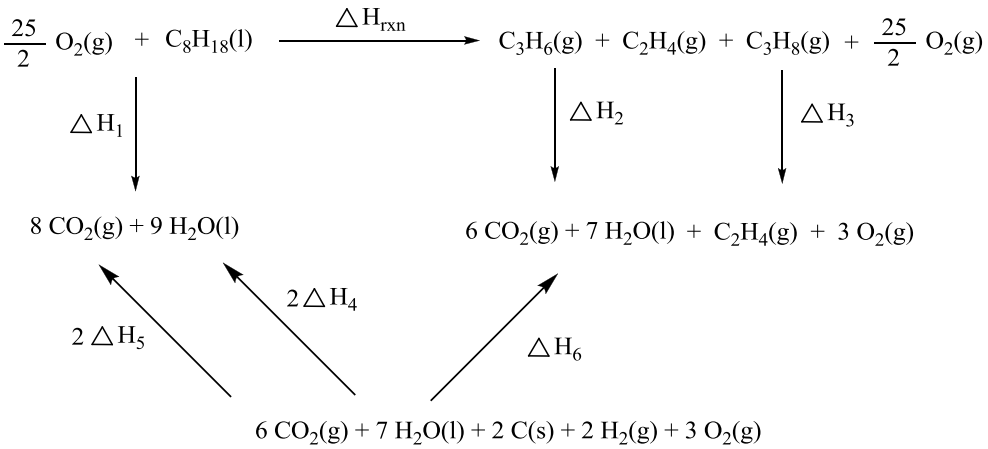
1

Marks

4. (a) Unglazed porcelain pieces/ Al_2O_3/ SiO_2 1

In the presence of air, octane undergoes combustion instead of cracking 1

(b)



2

$\triangle H_{rxn}$ = (-5476) – 2(-394) – 2(-286) + (+52) – (-2220) – (-2058) 1

= + 214 $kJmol^{-1}$ 1

Therefore, when 1 g octane undergoes cracking,

Enthalpy change = $\dfrac{214}{8(12)+18(1)} = +\ 1.88\ kJg^{-1}$ 1

(c) The reaction has to be conducted at high temperature. The direct measurement of temperature change of a heating system is technically difficult. 1

(d) Percentage atom economy = $\dfrac{3(12)+6(1)}{8(12)+18(1)} \times 100\% = 36.8\%$ 1

The above reaction is not environmental friendly because

(Any TWO of the followings)

i. the energy has to be conducted at high temperature 2

ii. the percentage atom economy is too low

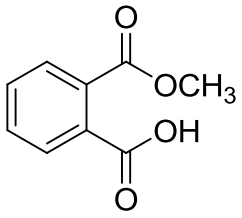
iii. the reaction involves the consumption of octane, which comes from petroleum (non-renewable energy source)

Accept other correct answers

				Marks
5	(a)	(i)	3d and 4s subshells in iron are of similar energy levels, the electrons in both subshell are available for bonding.	1
			Iron can form ions by losing different numbers of electrons or form covalent bonds by sharing different number of electrons.	0.5
		(ii)	Electronic configuration of Fe^{2+}: [Ar] $3d^6$	
			Electronic configuration of Fe^{3+}: [Ar] $3d^5$	0.5
			Fe^{3+} has a half-filled 3d subshell. It has extra stability.	1
	(b)	(i)	$4\ FeO_4^{2-}(aq) + C_2H_5OH\ (aq) + 7\ H_2O(l)$	
			$\rightarrow 4\ Fe(OH)_3(s) + 8\ OH^-(aq) + 2\ CO_2(g)$	1.5
			[0.5 marks for physical states]	
		(ii)	$2\ FeO_4^{2-}(aq) + 6\ SO_4^{2-}(aq) + 16\ H^+(aq)$	
			$\rightarrow 2Fe^{3+} + 3\ S_2O_8^{2-}(aq) + 8\ H_2O(l)$	1.5
			[0.5 marks for physical states]	
	(c)		The central atom in polyatomic ions with high oxidization state are highly electron deficient.	1
			Therefore, polyatomic ion has a high tendency to accept electrons from reducing agent in order to reduce the positive charge density of the central atoms	1

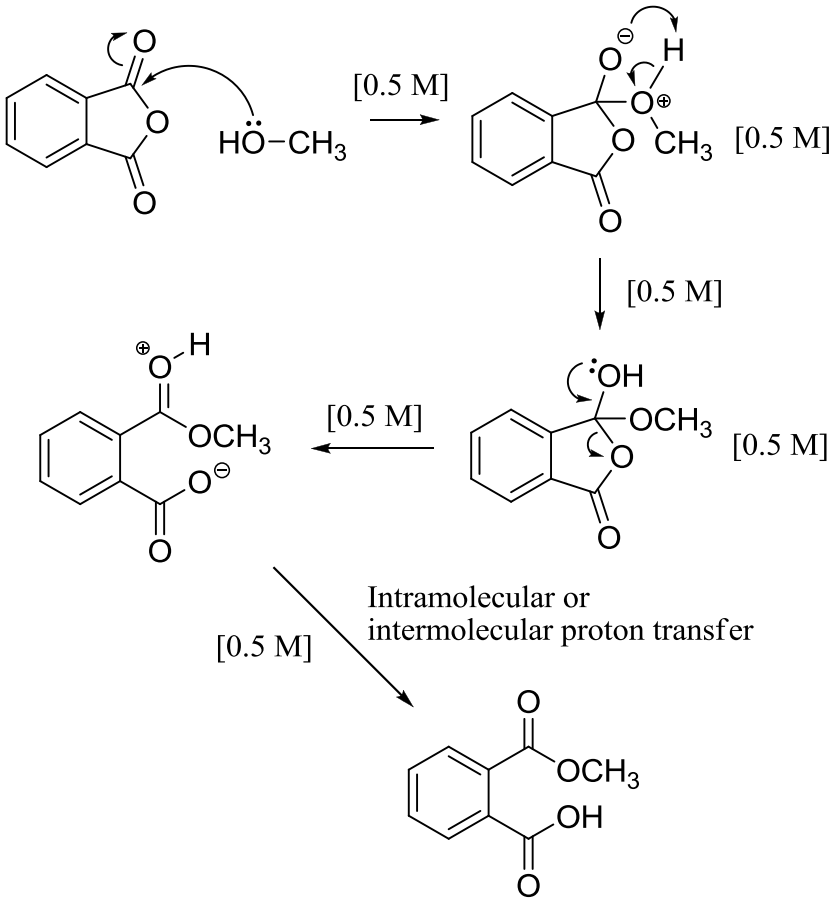
Marks

6 (a)



1

(b)



3

(c) Fluorine is highly electronegative. It can exert an negative inductive effect 0.5
to reduce the electron density of the oxygen atom in trifluoromethanol 0.5
Therefore, the trifluoromethanol is not nucleophilic enough to attack the carbonyl oxygen of Reactant X. 1

6	(d)	Reaction rate increases.	0.5
		The methyl ketone can exert a negative mesomeric effect to the benzene ring through resonance.	0.5
		This effect can enhance the partial positive charge density of the carbonyl oxygen atom of the reactant.	0.5
		Therefore, Reactant Z is more susceptible to the nucleophilic attack of methanol.	0.5

			Marks
7	(a)	C	1
	(b)	A	1

			Marks
8	(a)	$Na_2CO_3(aq) + 2\ KHC_4O_6(aq) \rightarrow 2\ NaKC_4O_6(aq) + CO_2\ (g) + H_2O(l)$	2
	(b)	Both the unreacted starting material and the product is water soluble.	0.5
		If the mole ratio between sodium carbonate and potassium bitartrate is not 1 : 2, the produced obtained will be contaminated by the excess reagent.	0.5
	(c)	To prevent the loss of product as a result of precipitation in cold solvent.	1
	(d)	Number of mole of $KNaC_4O_6 = \frac{33.0}{39.1+23.0+4(12)+6(16)} = 0.16$ mol	0.5
		Mass of water in the hydrated sample = 44.5-33.0 = 11.5 g	0.5
		Number of mole of water $= \frac{11.5}{2(1)+16} = 0.64$ mol	0.5
		Value of y = $\frac{0.64}{0.16} = 4$	0.5
	(e)	Number of mole of $KNaC_4O_6 \cdot 4H_2O$ = Number of mole of $KNaC_4O_6 = 0.16$ mol	0.5
		Number of mole of potassium bitartrate = $2(\frac{100}{1000}) = 0.2$ mol	0.5
		Percentage yield of the reaction = $\frac{0.16}{0.2} \times 100\% = 80\%$	1
	(f)	Melting point test	0.5
		Pure sample should have a sharp melting point range	0.5
		(or test the purity of the sample using NMR)	
	(g)	Food Additives	1

Marks

9 (a) (i) $H_4EDTA + 4\ OH^- \rightarrow EDTA^{4-} + 4\ H_2O$

Or 1

$H_4C_{10}H_{12}N_2O_8 + 4\ OH^- \rightarrow C_{10}H_{12}N_2O_8^{4-} + 4\ H_2O$

The function of sodium hydroxide is to deprotonate H_4EDTA and convert it to a negatively charged ligand. 0.5

This can increase the nucleophilicity of the ligand toward iron(III) ion. 0.5

(ii) Number of mole of H_4EDTA

$$= \frac{4}{10(12)+16(1)+2(14)+8(16)} = 0.0137 \text{ mol}$$

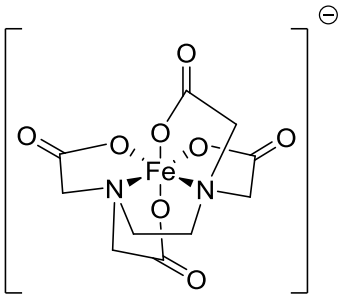
Number of mole of NaOH

$$= 2(\frac{27.4}{1000}) = 0.0548 \text{ mol}$$ 0.5

$$\frac{\text{Number of mole of } H_4EDTA}{\text{Number of mole of NaOH}} = \frac{1}{4}$$ 0.5

If excess sodium hydroxide is used, the excess hydroxide will undergo precipitation with the iron(III) chloride solution to form iron(III) hydroxide, which will reduce the yield of the reaction. 0.5 0.5

(iii)



2

[deduct 1 mark for missing the charge]

Marks

(iv) Number of mole of Fe^{3+} = number of mole of $FeCl_3 \cdot 6H_2O$

$= \frac{3.33}{55.8 + 3(35.5) + 6(18)} =$ 0.0123 mol 0.5

0.5

Fe^{3+} is the limiting reagent

Number of mole of NaFeEDTA

$= \frac{1.63}{23.0 + 55.8 + 10(12) + 12(1) + 2(14) + 8(16)} = 0.00421$ mol 0.5

Percentage yield of the reaction = $\frac{0.00421}{0.0123} \times 100\% = 34.3\ \%$ 0.5

(b) No observable change. 1

Reason: $ETDA^{4-}$ is a hexadentate ligand, it strongly chelate to the iron(III) ion to form a stable complex with a large stability constant. The ligand strength of NaSCN is not strong enough to displace $EDTA^{4-}$. 0.5 0.5

[Award 0 mark for wrong explanation]

Marks

12. Chemical knowledge (10 marks) max 1

Chemical knowledge covers five areas A, B, C, D, E

A. Lead compound discovery max. 2

- process of searching for biologically active compounds for treating the disease of interest
- Usually extracted from plants or animals
- The mechanistic study of the biological effect of the drug is studied.
- Examples: discovery of salicylic acid from willow or
  discovery of cis-platin from the effect of electromagnetic radiation of the growth of bacterium Escherichia coli (E.coli.).

B. Molecular modification max 2

- Brief introduction of generally mechanism for the reaction between drugs and compounds in human body (i.e. the active site of the enzyme is a 3-dimensional site which forms a "key and lock structure" with that of the active enantiomer
- structure of the lead compounds (e.g. the shape of the substituent) is modified many times by chemical reactions to optimize its ability to bind to the active site of the enzyme and to reduce the side effect of the drugs.
- Example: The acetylation of salicylic acid to form methyl salicylate in order to reduce the acidity of drugs

C. Formulation development max 2

- The lead compounds are usually combined with other drugs, which may enhance the effect of the new drug or relieve the side effect produced by new drug on the human body.
- Examples: Addition of additives like buffers in order to control the acidity of the aspirin.
  Mannitol is prescribed to increase urine flow to counter renal failure of cis-platin
  Anti-emetic drugs was intensively used to resolve the nausea and vomiting effect of csi-platin

D. Safety tests and human trials max 2

There are two stages to ensure the safety of new drugs:

Pre-clinical trial

- carried out by microbiologists and pharmacologists on tissue samples and live animals.
- provide useful information on the drug's absorption, transportation inside the body, toxicity, metabolism and elimination in the body.
- Many drugs are rejected at this stage because they are shown to be too toxic or not effective.

Clinical trial

- In the clinical test, the factors (e.g. age, sex, other disorders and the use of other drug) affecting the drug efficiency on the human being will be thoroughly studied.

E. Approval for marketing from the government-monitoring agency max 1

- If the drug is proved to be effective and safe, it will be considered to be manufactured in large scale for marketing.
- If the drug is approved, the manufacturers must monitor the use of the drug and promptly report to the government-monitoring agency

Organization (6 marks) (1/2 marks awarded)

mark for C.K.	Max. for Orgn.
10-8	6
7	5
6	4
5-4	3
3-2	2
1-0	1

General Guidelines for marking Organization

(i) The essay should be clearly ORGANISED, with suitable DIVISIONS, PARAGRAPHS AND SUB-HEADINGS. These should be clear to the reader.

(ii) Terms must be clearly defined

(iii) The essay should be LOGICALLY organized. It must not be a list of facts.

(iv) The essay should not contain a lot of irrelevant/ superfluous materials.

Presentation (4 marks) (1/2 marks awarded)

This mark is awarded for the ability to present the organized Chemical Knowledge in a suitable, meaningful and reasonable form.

NOTE: Marks awarded should be related to Chemical Knowledge.

mark for C.K.	Max. for presentation
10-7	4
6-5	3
4-3	2
≤ 2	1

The following are looked for:
EQUATIONS, DIAGRAMS AND EXAMPLES

ENGLISH This mark is for the ability to express clearly in English

Marks

12. Chemical knowledge (10 marks)

Chemical knowledge covers three areas A, B, C.

A. Introduction of carboxylic acid derivatives. max.1

- Lewis structure of acyl chloride, acid anhydride, ester and amide and their preparation.

B. Determination of reactivity of carboxylic acid derivatives by: max 5

(i) the magnitude of the partial positive charge density of the carbonyl carbons

e.g. acyl chloride: poor overlapping between the p-orbitals between the carbonyl carbon and chlorine atom. It is the most reactive among the four derivatives.

(ii) the stability of the leaving groups.

ease of leaving group: Cl^- > $RCOO^-$ > RO^- > NR_2^-

(Explanation of stability of leaving group by inductive or mesomeric effects are required)

Examples to compare the derivatives of carboxylic acids:

E.g. $NaBH_4$ can react with acyl chloride but not ester

Acyl chloride can be hydrolyzed by pure water while amide cannot.

Etc…

C. Inter-conversion between derivatives of acids max 4

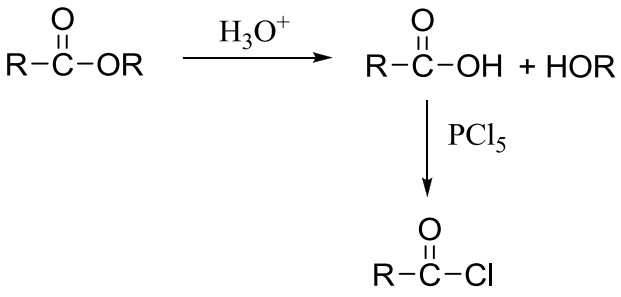
(i) Direct conversion from the more reactive derivatives to less reactive derivatives are possible:

e.g. $RCOCl + HOR \rightarrow RCOR + HCl$

$RCOOOR + NH_3 \rightarrow RCONH_2 + HOR$

(ii) The less derivatives can be hydrolyzed to carboxylic acids, followed by converting it to a more reactive derivatives

e.g.



Organization (6 marks) (1/2 marks awarded)

mark for C.K.	Max. for Orgn.
10-8	6
7	5
6	4
5-4	3
3-2	2
1-0	1

General Guidelines for marking Organization

(v) The essay should be clearly ORGANISED, with suitable DIVISIONS, PARAGRAPHS AND SUB-HEADINGS. These should be clear to the reader.

(vi) Terms must be clearly defined

(vii) The essay should be LOGICALLY organized. It must not be a list of facts.

(viii) The essay should not contain a lot of irrelevant/ superfluous materials.

Presentation (4 marks) (1/2 marks awarded)

This mark is awarded for the ability to present the organized Chemical Knowledge in a suitable, meaningful and reasonable form.

NOTE: Marks awarded should be related to Chemical Knowledge.

mark for C.K.	Max. for presentation
10-7	4
6-5	3
4-3	2
≤ 2	1

The following are looked for:
EQUATIONS, DIAGRAMS AND EXAMPLES

ENGLISH This mark is for the ability to express clearly in English