THE 13TH HONG KONG DIPLOMA OF SECONDARY EDUCATION MOCK EXAMINATION 2024

第十三屆全港 DSE 模擬試 2024

CHEMISTRY
化學

Paper 1
卷一

Section A
甲部

1	D	**11**	A	**21**	A	**31**	C
2	B	**12**	B	**22**	D	**32**	A
3	A	**13**	A	**23**	D	**33**	C
4	C	**14**	D	**24**	D	**34**	C
5	B	**15**	B	**25**	D	**35**	A
6	A	**16**	D	**26**	D	**36**	A
7	B	**17**	D	**27**	A		
8	D	**18**	B	**28**	C		
9	B	**19**	B	**29**	D		
10	A	**20**	D	**30**	A		

Section B

乙部

1. (a) Copper pieces change from reddish brown to black. / Black powder forms. 1

$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$ 1

(b) To allow the oxygen in the syringe to have enough time for complete reaction with copper. 1

(c) Percentage by volume of oxygen in air $= \frac{(60.0 - 47.5)\ cm^3}{60.0\ cm^3}$ 1

$= 20.8\%$ 1

(d) Carbon powder cannot be used to replace crushed copper pieces. Carbon reacts with oxygen to give carbon dioxide. The final volume of gas cannot represent the amount of oxygen consumed. 1

(e) Different gas components in air have different boiling points. 1

The gas component having a lower boiling point will be distilled out and collected first at the higher level of the fractionating tower. 1

8

2. (a) As aluminium is reactive, aluminium compounds are relatively stable. Hence, aluminium is extracted by the electrolysis of its compound. 1

(b) (i) To reduce the melting point of Al_2O_3 so as to reduce the use of fuels. 1

(ii) Graphite has a high melting point. / Graphite is an inert electrode. 1

(c) (i) $Al^{3+}(l) + 3e^- \rightarrow Al(l)$ 1

(ii) +3 1

(iii) Na^+ is a weaker oxidizing agent than Al^{3+} and so Na^+ will not be preferentially reduced to Na. 1

(d) (i) $2O^{2-}(l) \rightarrow O_2(g) + 4e^-$ 1

(ii) Carbon dioxide (The oxygen formed at the anode may react with carbon at high temperatures.) 1

8

3. (a) A primary cell is a chemical cell which is not rechargeable. 1

(b) (i) $Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$ 1

(ii) $Ag_2O(s) + H_2O(l) + 2e^- \rightarrow 2Ag(s) + 2OH^-(aq)$ 1

(c) To power small electrical appliances such as quartz watches / calculators / hearing aids / pacemakers. (Accept other reasonable answers) 1

(d) (i) The circuit is not complete. 1

(ii) Join the two half cells by a strip of filter paper soaked with sodium nitrate solution. 1

(iii) $5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$ 1

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4. (a) $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

Number of moles of NaOH reacted with H_2SO_4

$= 2.0 \text{ mol dm}^{-3} \times \frac{25.50}{1000} \text{ dm}^{-3} = 0.051 \text{ mol}$

From the equation, mole ratio of H_2SO_4 : NaOH = 1 : 2.

$\therefore$ number of moles of unreacted $H_2SO_4 = \frac{0.051 \text{ mol}}{2} = 0.0255 \text{ mol}$

Number of moles of H_2SO_4 reacted with NH_3

$= 1.0 \text{ mol dm}^{-3} \times \frac{50}{1000} \text{ dm}^3 - 0.0255 \text{ mol} = 0.0245 \text{ mol}$ 1

$H_2SO_4(aq) + 2NH_3(aq) \rightarrow (NH_4)_2SO_4(aq)$

Number of moles of ammonia absorbed = 0.0245 mol × 2 = 0.049 mol 1

(b) Percentage by mass of $NH_4^+ = \frac{0.049 \text{ mol} \times (14.0 + 1.0 \times 4) \text{ g mol}^{-1}}{9.6 \text{ g}} \times 100\%$ 1

= 9.19% 1

(c) From the chemical formula, $\frac{\text{Number of moles of } NH_4^+}{\text{Number of moles of } SO_4^{2-}} = \frac{2x}{1+x}$ 1

Number of moles of $SO_4^{2-} = \frac{9.6 \text{ g} \times 49\%}{(32.1 + 16.0 \times 4) \text{ g mol}^{-1}} = 0.049 \text{ mol}$

$\frac{0.049}{0.049} = \frac{2x}{1+x}$

$x = 1$ 1

Mark

Molar mass of the double salt $= \frac{9.6\text{ g}}{0.0245\text{ mol}} = 392\text{ g mol}^{-1}$ 1

$55.8 + 2 \times (32.1 + 16.0 \times 4) + 2 \times (14.0 + 1.0 \times 4) + y(1.0 \times 2 + 16.0) = 392$

$y = 6$ 1

8

5. (a) $C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l) \qquad \Delta H = -3268\text{ kJ mol}^{-1}$ 1

(b) Number of moles of benzene required $= \frac{200\text{ kJ}}{3268\text{ kJ mol}^{-1}} = 0.0612\text{ mol}$ 1

Mass of benzene required = $(12.0 \times 6 + 1.0 \times 6)\text{ g mol}^{-1} \times 0.0612\text{ mol} = 4.77\text{ g}$ 1

Volume of benzene required $= \frac{4.77\text{ g}}{0.88\text{ g cm}^{-3}} = 5.42\text{ cm}^3$ 1

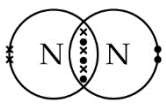
(c) Any TWO:

There was heat loss to the surroundings / incomplete combustion occurred / the heat capacities of the metal can and the thermometer were not taken into account / the experiment was not carried out under standard conditions. 2

6

6. (a) The components in air have different boiling points. The gas with a lower boiling point will boil off first. 1

(b) (i)



1

(ii) Nitrogen has a simple molecular structure. 1

The molecules are held together by weak van der Waals' forces only. 1

(c) (i) Under high temperatures, *A* (nitrogen) reacts with *B* (oxygen) to give nitrogen monoxide. 1

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ 1

(ii) It damages plants / kills aquatic life / corrodes building materials / corrodes metal objects. 1

(d) 1 1

8

7. (a) Zinc has a giant metallic structure. 1

There is a sea of delocalized electrons for conducting electricity. 1

(b) (i) The layer of zinc prevents iron from contacting air and water. 1

(ii) Yes. Zinc is more reactive than iron. 1

When the zinc coating is damaged, zinc acts as a sacrificial metal. It will corrode instead of iron. 1

(c) (i) Any TWO of the following: 2

The sample dissolves / colourless gas bubbles evolve / some brown solids remain.

(ii) Mole ratio of Zn : Al : Cu $= \frac{5.494}{65.4} : \frac{0.566}{27.0} : \frac{8.001}{63.5}$ 1

$= 0.0840 : 0.0210 : 0.126 = 4 : 1 : 6$

$\therefore$ empirical formula of the alloy is Zn_4AlCu_6. 1

9

8. – $C < B < A$ 1

– Propan-1-ol molecule, propane-1,3-diol molecule and propane-1,2,3-triol molecule are mainly held together by hydrogen bonds. 1

– Each propan-1-ol molecule can form one hydrogen bond on average, while each propane-1,3-diol molecule and propane-1,2,3-triol molecule can form two and three hydrogen bonds on average respectively.

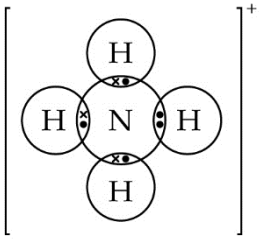
– The intermolecular forces between propan-1-ol molecules are the weakest while those between propane-1,2,3-triol molecules are the strongest. Hence, propan-1-ol is the most volatile while propane-1,2,3-triol is the least volatile. 1

Mark

– Communication mark 1

5

9. (a)



1

The nitrogen atom has a lone pair of electrons. It contributes the lone pair of electrons by sharing with the hydrogen ion and so a dative covalent bond forms. 1

(b) (i) The value of K_c remains unchanged as K_c is not affected by the concentrations of the reactants or products. 1

(ii) The value of K_c will change as temperature can alter the value of K_c. 1

(c) (i) Let x mol dm^{-3} be the change in concentration of $NH_3(aq)$.

Concentration (mol dm^{-3})	$NH_3(aq)$	+ $H_2O(l)$ $\rightleftharpoons$	$NH_4^+(aq)$	+ $OH^-(aq)$
Initial	0.75	/	0	0
Change	$-x$	/	$+x$	$+x$
Equilibrium	$0.75 - x$	/	x	x

$$K_c = \frac{[NH_4^+(aq)]_{eqm}[OH^-(aq)]_{eqm}}{[NH_3(aq)]_{eqm}}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.75 - x}$$ 1

Solving for x,

$x = 0.00367$ or -0.0038 (rejected) 1

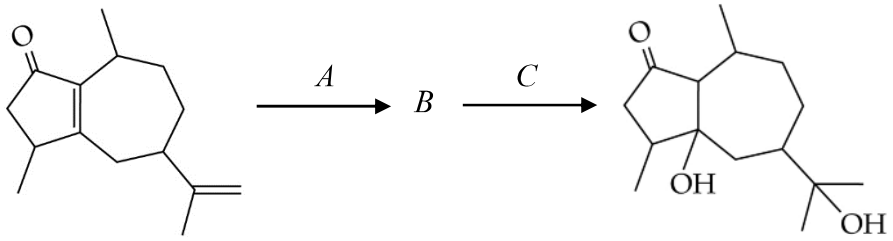
$\therefore [OH^-(aq)]_{eqm} = 0.00367$ mol dm^{-3}

(ii) pOH = – log (0.00367) = 2.44 1

pH = 14 – pOH = 14 – 2.44 = 11.6 1

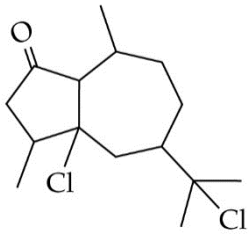
8

10.



A: HCl(aq) 1

B:



1

C: NaOH(aq), heat (under reflux) 1

3

11. (a) Manganese exhibits variable oxidation numbers (from +2 to +7) / manganese compounds can act as a catalyst (e.g. $MnO_2(s)$ speeds up the decomposition of H_2O_2) / manganese forms coloured compounds (e.g. $Mn^{3+}(aq)$ is red and $MnO_4^-(aq)$ is purple). 1

(b) $2MnO_4^-(aq) + 3SO_3^{2-}(aq) + H_2O(l) \rightarrow 2MnO_2(s) + 3SO_4^{2-}(aq) + 2OH^-(aq)$ 1

(c) No brown precipitate forms as no $MnO_2(s)$ is produced. 1

3

12. (a) $Zn(s) + I_2(aq) \rightarrow Zn^{2+}(aq) + 2I^-(aq)$ 1

(b) $I_2(aq)$ 1

(c) Iodine solution was in excess as the colour intensity of the reaction mixture did not drop to zero. 1

(d) The initial rate could be obtained by finding the slope of tangent at time $t = 0$. 1

(e) (i) When a diluted iodine solution was used, the reactant particles had a smaller chance to collide. 1

This decreased the number of effective collisions per unit time. 1

(ii) Mass / size of the zinc plate / volume of the iodine solution used / temperature of the reaction mixture 1

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Paper 2
卷二

Section A Industrial Chemistry

1. (a) (i) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ (1)

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ (1)

(ii) A high pressure shifts the equilibrium position of the reaction system to the product side. (1)

However, the construction cost and maintenance cost of pipelines that can withstand high pressure are high. (1)

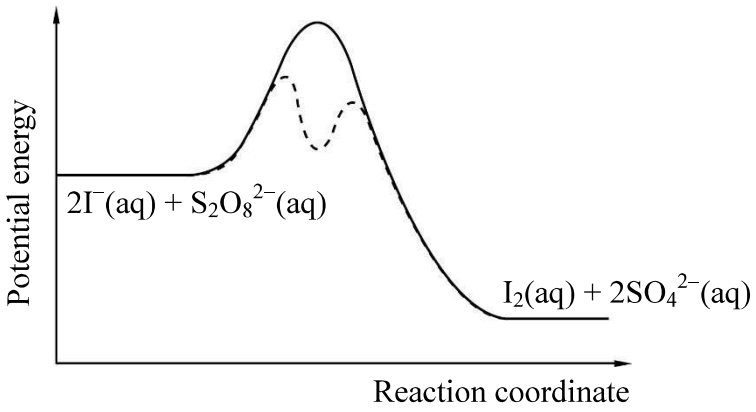
(iii) Activation energy = (160 + 9) kJ mol^{-1} = 169 kJ mol^{-1} (1)

(b) (i) The reaction involves collisions of two types of negatively charged ions. Thus, the activation energy of the reaction is large. (1)

(ii) $2I^-(aq) + 2Fe^{3+}(aq) \rightarrow I_2(aq) + 2Fe^{2+}(aq)$ (1)

$2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow 2SO_4^{2-}(aq) + 2Fe^{3+}(aq)$ (1)

(iii)



Presence of an intermediate (1)

Curve with E_a lower than the uncatalysed reaction (1)

(c) (i) Using a colorimeter to measure the variation of absorbance of the reaction mixture with time (1)

(ii) (1) Slope of tangent for Experiment I

$$= \frac{0.010 - 0.002}{0 - 24}\ \text{M min}^{-1} = -3.33 \times 10^{-4}\ \text{M min}^{-1} \quad (1)$$

Slope of tangent for Experiment II

$$= \frac{0.010 - 0.002}{0 - 12}\ \text{M min}^{-1} = -6.67 \times 10^{-4}\ \text{M min}^{-1} \quad (1)$$

(2) When the concentration of OH^- is doubled, the initial rate doubles. Hence, the order of reaction with respect to OH^- is 1. (1)

(3) Rate = $k\,[N][OH^-]$ (1)

(4) Using the results of Experiment I,

$3.33 \times 10^{-4}\ \text{M min}^{-1} = k\,(0.01\ \text{M})(0.5\ \text{M})$ (1)

$k = 0.067\ \text{M}^{-1}\ \text{min}^{-1}$ (1)

(d) (i) For Pathway I, the overall reaction is:

$$Al_2O_3 + 2NaOH + H_2O + H_2SO_4 \rightarrow 2Al(OH)_3 + Na_2SO_4$$

$$\text{Atom economy} = \frac{78.0 \times 2}{102.0 + 40.0 \times 2 + 18.0 + 98.1} \times 100\% = 52.3\% \quad (1)$$

For Pathway II, the overall reaction is:

$$2Al + 3H_2SO_4 + 6NaOH \rightarrow 2Al(OH)_3 + 3Na_2SO_4 + 3H_2$$

$$\text{Atom economy} = \frac{78.0 \times 2}{27.0 \times 2 + 98.1 \times 3 + 40.0 \times 6} \times 100\% = 26.5\% \quad (1)$$

Hence, Pathway I is greener.

(ii) Al_2O_3. The extraction of Al_2O_3 from aluminium ores involves fewer chemical processes than the extraction of Al from aluminium ores. (1)

Section B Materials Chemistry

2. (a) (i) (1) Each carbon atom in diamond forms four single covalent bonds with four other neighbouring atoms. (1)

Each carbon atom in carbon nanotube forms three single covalent bonds with three other neighbouring atoms. (1)

(2) They have delocalized electrons which are responsible for conducting electricity. (1)

(ii) Cholesteric phase (1)

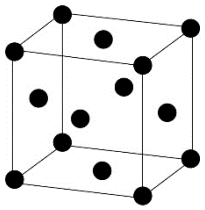
(iii) Cellulose has a strong network of intermolecular hydrogen bonds. Water molecules cannot form hydrogen bonds easily with hydroxyl groups on the cellulose polymer chains. (1)

(b) (i) It acts as a reducing agent to reduce silver ions to silver metal. (1)

(ii) $Ag^+(aq) + e^- \rightarrow Ag(s)$ (1)

(iii) A bright yellow colloid is produced. (1)

(iv) (1)



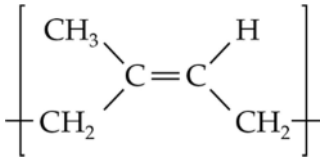
(1)

(2) Number of silver atoms = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$ (1)

(v) Bulk silver can be used in making jewellery / coins / electrical and electronic components. (1)

Silver nanoparticles can be used as an anti-bacterial agent in refrigerators, air conditioners and washing machines. (1)

(c) (i)



(1)

(ii) Heat natural rubber with a small amount of sulphur. (1)

(c) (iii) (1) A thermosetting plastic is a plastic which, once set hard, cannot be softened again by heating. (1)

(2) There are cross-links between the polymer chains of vulcanized rubber. (1)

(3) Compression moulding (1)

(iv) It is resistant to abrasion / impermeable to gases / highly resistant to chemicals. (1)

(v) Vulcanized rubber is non-biodegradable. (1)

The incineration of vulcanized rubber would produce toxic sulphur dioxide. (1)

(Accept other reasonable answers)

Section C Analytical Chemistry

3. (a) (i) Test the solution with litmus paper. (1)

The paper will turn white. (1)

OR Add HCl(aq) to the solution. (1)

A gas with pungent smell of bleaching solution will be produced. (1)

(ii) Different pigments in leaves have different solubilities in the water on paper fibres (stationary phase) and in the developing solvent (mobile phase). (1)

The pigment that is more soluble in the developing solvent will move up the paper faster. (1)

(iii) Colorimetry / infrared spectroscopy (1)

(b) (i) Chain isomerism (1)

(ii) (1) A strong absorption peak at 1740 cm^{-1} corresponds to the C=O bond. (1)

A strong and broad absorption peak at 3000–3500 cm^{-1} corresponds to the O–H bond. (1)

(2) Infrared spectroscopy can be used as the fingerprint region in an infrared spectrum is unique for a particular compound. The identity of *A* and *B* can be determined by comparing their spectra with the known spectra. (1)

(iii) There is a peak at m/z = 29 in the spectrum of *A* but not in the spectrum of *B*. (1)

Only *A* can produce a fragment ion of $CH_3CH_2^+$. (1)

(accept other reasonable answers)

(iv) Add Na_2CO_3(aq) / $NaHCO_3$(aq) to the two compounds. (1)

Only *A* gives a colourless gas that turns limewater milky. (1)

(accept other reasonable answers)

(c) (i) Step 1: $6I^-(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \rightarrow 3I_2(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$ (1)

Step 3: $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ (1)

(ii) Number of moles of $I^-(aq) = 0.8 \text{ mol dm}^{-3} \times \frac{25.0}{1000} \text{dm}^3 = 0.02 \text{ mol}$

Number of moles of $Cr_2O_7^{2-}(aq)$

$= 0.075 \text{ mol dm}^{-3} \times \frac{25.0}{1000} \text{dm}^3 = 1.88 \times 10^{-3} \text{ mol}$

Number of moles of $I_2(aq)$ generated in Step 1

$= 1.88 \times 10^{-3} \text{ mol} \times 3 = 5.64 \times 10^{-3} \text{ mol}$ (1)

Number of moles of $I_2(aq)$ generated in 10.0 cm^3 mixture

$= 5.64 \times 10^{-3} \text{ mol} \times \frac{10.0 \text{ cm}^3}{100.0 \text{ cm}^3} = 5.64 \times 10^{-4} \text{ mol}$

Number of moles of $I_2(aq)$ reacted with $S_2O_3^{2-}(aq)$

$= 0.05 \text{ mol dm}^{-3} \times \frac{12.50}{1000} \text{dm}^3 \times \frac{1}{2} = 3.13 \times 10^{-4} \text{ mol}$ (1)

Number of moles of $I_2(aq)$ reacted with vitamin C in 10.0 cm^3 mixture

$= 5.64 \times 10^{-4} \text{ mol} - 3.13 \times 10^{-4} \text{ mol} = 2.51 \times 10^{-4} \text{ mol}$

Number of moles of $I_2(aq)$ reacted with vitamin C in 100.0 cm^3 mixture

$= 2.51 \times 10^{-4} \text{ mol} \times \frac{100.0 \text{ cm}^3}{10.0 \text{ cm}^3} = 2.51 \times 10^{-3} \text{ mol}$ (1)

Number of moles of vitamin C in the tablet $= 2.51 \times 10^{-3}$ mol

Mass of vitamin C in the tablet

$= 2.51 \times 10^{-3} \text{ mol} \times (12.0 \times 6 + 1.0 \times 8 + 16.0 \times 6) \text{ g mol}^{-1} = 0.442 \text{ g}$ (1)

(iii) Other substances in the tablet may affect the titration results. (1)

– END –