ACCESS EDUCATION

# ACCESS EDUCATION 2017

# CHEMISTRY Unit 3 & 4

## Trial Examination – Suggested Solutions

### Section A

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

**Question 1**

Different quantities of nitrogen oxide (NO) are listed below. Which one contains the least number of molecules?

A. 6 x $10^2$ L at 273 K and 1 atm — $V/V_M$ = 6 x $10^2$ /22.4 (STP) = 27 mole

***B. 6 x $10^{23}$ molecules*** — $N_A$ = 1 mole

C. 6 x $10^2$ g — 6 x $10^2$ g / 32.0 $gmol^{-1}$ = 20 mole

D. 6 mol — 6 mole

**Question 2**

In which one of the following compounds does the transition metal display the lowest oxidation state?

A. $CrO_3$ — +6 (3 x -2)

***B. $Cu_2S$*** — +1 (-2)

C. $MnCl_2$ — +2 (2 x -1)

D. $K_2Cr_2O_7$ — +6 (2 x +1  7 x -2)

**Question 3**

A chemical reaction has a ΔH of 150 kJ $mol^{-1}$ and the activation energy for its reverse reaction is 350 kJ $mol^{-1}$.
The activation energy of the forward reaction is

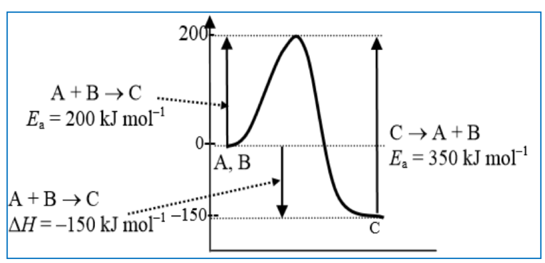
A. + 500 kJ $mol^{-1}$

***B. + 200 kJ $mol^{-1}$***

C. + 150 kJ $mol^{-1}$

D. – 200 kJ $mol^{-1}$

If A + B $\longrightarrow$ C




**Question 4**

Which of the following statements about enzymes are correct?

*I  Enzymes are proteins.*

*II  Enzymes increase the rate of biochemical reactions.*

**III** Enzymes increase the equilibrium constant of biochemical reactions. (No - only ΔTemp can alter K)

***A. I and II only***

B. I and III only

C. II and III only

D. I, II and III

**Question 5**

In coal fired power stations, the amount of electrical energy produced is less than half of the chemical energy of the coal consumed. This is mainly due to:

A. the incomplete combustion of the coal and partial releases of its chemical energy for the generation process

***B. the less than 100 % efficiencies of the energy transformation that occur at the power station***

C. the number of energy transformations required to convert the chemical energy from the coal into electrical energy

D. the large amounts of energy required to convert water into steam that is used in the generation process

| |
|---|
| Coal fired power stations have efficiencies of about 35 % - 45 %. The main reason for this low efficiency is due to the less than 100 % efficiencies in each of the energy transformation steps in the generation process. |

**Question 6**

The electrolyte used to produce the major proportion of the chlorine gas commercially produced using electrolytic cells is

A. a molten mixture containing calcium chloride and sodium chloride

B. concentrated aqueous hydrochloric acid

***C. concentrated aqueous sodium chloride***

D. dilute aqueous sodium chloride

| |
|---|
| The majority of the chlorine gas commercially produced is a by-product of sodium hydroxide production. This process uses concentrated aqueous sodium chloride (brine) solutions as the electrolyte. In this cell the chloride ions are oxidised at the anode to form chlorine, while hydrogen and hydroxide ions are formed at the cathode, following the reduction of water. Anode reaction: $2Cl^-_{(aq)} \rightleftharpoons Cl_{2\,(g)} + 2e^-$ : Cathode reaction: $2H_2O_{(l)} + 2e^- \rightleftharpoons H_{2\,(g)} + 2OH^-_{(aq)}$ |

**Question 7**

The oxidation of sulfur dioxide, $SO_2$, can be represented by the following chemical equation

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)} \ : \ \Delta H = -198 \text{ kJ mol}^{-1}$$

Adding more than the stoichiometric amount of oxygen to a sample of sulfur dioxide will:

***A. increase the equilibrium yield of sulfur trioxide***

B. decrease the value of the equilibrium constant

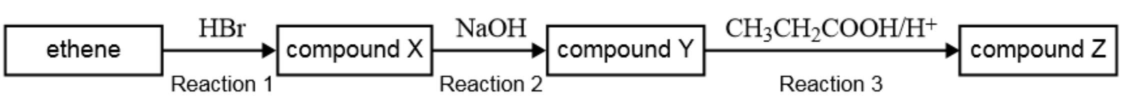
C. increase the value of the equilibrium constant

D. decrease the equilibrium yield of sulfur trioxide

| |
|---|
| Addition of oxygen will shift the position of equilibrium to favour the formation of sulfur trioxide thus increasing the equilibrium yield, based on Le Chatelier's Principle. Adding or removing reactants or products shifts the position of equilibrium but has no effect on the value of the equilibrium constant. |

*Questions 8 and 9 refer to the following information.*

Ethene can be converted into other carbon-containing compounds using the reagents shown in this flow chart.




**Question 8**

Compounds X, Y and Z are, respectively

A. bromoethane, ethanol, propyl ethanoate

***B. bromoethane, ethanol, ethyl propanoate***

C. bromoethene, ethanoic acid, ethyl propanoate

D. bromoethene, ethene hydroxide, propyl ethanoate

**Reaction 1**. $CH_2 = CH_2 \longrightarrow CH_3CH_2Br$ (bromoethane/addition)

**Reaction 2**. $CH_3CH_2Br \longrightarrow CH_3CH_2OH$ (ethanol/substitution)

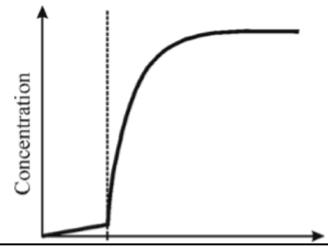
**Reaction 3**. $CH_3CH_2COOH + CH_3CH_2OH \longrightarrow CH_3CH_2COOCH_2CH_3 + H_2O$
ethyl propanoate/condensation

**Question 9**
Reactions 1, 2 and 3 can be described as, respectively

A. addition, addition, neutralisation
***B. addition, substitution, condensation***
C. substitution, neutralisation, oxidation
D. substitution, substitution, condensation

**Question 10**
The graph below shows how the concentration of a product in a gas phase equilibrium reaction varied with time. A change to the system occurred at time t.

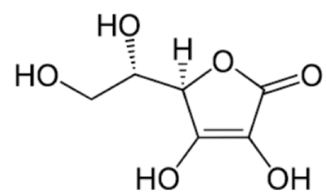
The best explanation for the change that occurred at time t is that




A. some of the product was removed from the mixture.
B. a catalyst was added to the mixture.
C. the temperature of the mixture was decreased.
***D. more reactant was added to the mixture.***

Following time t, the product concentration increases dramatically. This would require consumption of an increased amount of reactant. Adding a catalyst provides an alternative pathway for the reaction with a lower activation energy and can greatly increase the rate of reaction but not the yield of product.

**Question 11**
The structure of vitamin C is shown here:



Vitamin C is an important biological molecule and is often added to foods as an antioxidant. Based on this information, and on the structure of vitamin C shown above, it can be predicted that vitamin C is more soluble in

A. fats than in water and is a good oxidant.
B. fats than in water and is a good reductant.
C. water than in fats and is a good oxidant.
***D. water than in fats and is a good reductant.***

Vitamin C is water soluble (dipolar) and protects many foods against oxidation so it must be a reductant.

**Question 12**
A fuel cell currently under development for powering small electronic devices utilises the reaction of methanol, oxygen and an acidic electrolyte. The reductant in the cell reaction and the half reaction at the anode are:

| reductant | anode reaction |
|---|---|
| A. methanol | $O_{2\,(g)} + 4H^+_{(aq)} + 4e \rightarrow 2H_2O_{(l)}$ |
| B. oxygen | $O_{2\,(g)} + 4H^+_{(aq)} + 4e \rightarrow 2H_2O_{(l)}$ |
| ***C. methanol*** | $CH_3OH_{(g)} + H_2O_{(l)} \rightarrow CO_{2\,(g)} + 6H^+_{(aq)} + 6e^-$ Reductant causes reduction and is oxidised ($e^-$ loss) |
| D. oxygen | $CH_3OH_{(g)} + H_2O_{(l)} \rightarrow CO_{2\,(g)} + 6H^+_{(aq)} + 6e^-$ |

**Question 13**
The ester, propyl butanoate, is used as a food flavouring. The correct semi-structural formula for propyl butanoate is

***A.*** $CH_3CH_2CH_2COOCH_2CH_2CH_3$
B. $CH_3COOCH_2CH_2CH_2CH_2CH_3$
C. $CH_3CH_2CH_2CH_2CH_2COOCH_2CH_3$
D. $CH_3CH_2CH_2CH_2COOCH_2CH_2CH_3$

propanol + butanoic acid (+ production of $H_2O$)

$CH_3CH_2CH_2OH + CH_3CH_2CH_2COOH \rightarrow CH_3CH_2CH_2COOCH_2CH_2CH_3 + H_2O$

**Question 14**

Increasing the pressure of a gas phase reaction will result in an increase in the rate of reaction because

A. the particles will have a higher kinetic energy.

B. more particles will have energies greater than the activation energy, therefore there will be more fruitful collisions between the reactant particles.

C. the particles occupy a smaller volume.

***D. there will be a higher chance of fruitful collisions between the reactant particles***.

Increasing the pressure increases the likelihood of the reactant particles colliding, therefore it increases the chance that a fruitful collisions will result in product formation. Increasing the pressure alone has no effect on the average energy of the particles. The average energy of the particles is predominantly determined by the temperature of the system.

**Question 15**

The main advantage of using biodiesel to replace diesel fuel obtained from crude oil is that

A. biodiesel does not produce any greenhouse gases when it is burnt in engines

B. biodiesel is cheaper to produce than diesel fuels derived from crude oil

C. diesel derived from crude oil requires an expensive distillation process not required in biodiesel production

***D. fossil fuels are being consumed in diesel production, whereas biodiesel is produced from renewable materials***

The main advantage is that biodiesel is produced from renewable resources (eg vegetable oils). When biodiesel is combusted in engines, like all carbon based fuels, it will still release carbon dioxide which is a greenhouse gas.

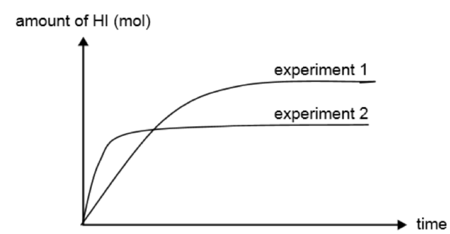
**Question 16**

Hydrogen iodide is produced by the reaction between hydrogen and iodine: $H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{(g)}$

Two experiments investigating this reaction were conducted.

<u>Experiment 1</u>: quantities of $H_{2\,(g)}$ and $I_{2\,(g)}$ were placed in a sealed vessel and the reaction allowed to proceed at constant temperature.

<u>Experiment 2</u>: experiment 1 was repeated, but at a different temperature. The graph below shows the amount of hydrogen iodide produced over the course of experiments 1 and 2.




These results show that experiment 2 was conducted at a:

A. lower temperature than experiment 1 and the reaction is endothermic

B. lower temperature than experiment 1 and the reaction is exothermic

C. higher temperature than experiment 1 and the reaction is endothermic

***D. higher temperature than experiment 1 and the reaction is exothermic***

Experiment 2 has a higher initial rate of reaction and so occurs at the higher temperature. Experiment 1 produces more HI by the time equilibrium is established, so the forward reaction is favoured at lower temperatures, indicating that the reaction is exothermic.

**Question 17**

Methane obtained from natural gas wells is considered as a non-renewable resource, yet methane generated by the anaerobic digestion of organic materials is classed as a renewable fuel because

A. it is a different material and has different properties

B. it is obtained from plant materials only

C. it does not contribute to greenhouse gas emissions

***D. it can be replaced in a short time frame from renewable resources***

Methane generated by the anaerobic digestion of organic materials can be replaced in a relatively short time by adding more renewable feedstock materials to the digestion reactor. Some of the feedstock materials used include sewage, garbage in landfills, animal waste or plant materials. Natural gas is a fossil fuel formed over millions of years and is therefore a non-renewable resource

**Question 18**

Hydrogen gas can be produced from a variety of methane sources. The equation for the reaction is:

$$CH_{4\,(g)} + 2H_2O_{\,(g)} + \quad \rightleftharpoons 4H_{2\,(g)} + \quad CO_{2\,(g)}$$

If the reaction is reversed, the expression for the equilibrium constant is:

***A.*** $K = \dfrac{[H_2O]^2\,[CH_4]}{[H_2]^4\,[CO_2]}$

B. $K = \dfrac{[H_2]^4\,[CO_2]}{[H_2O]^2\,[CH_4]}$

C. $K = \dfrac{[H_2O]\,[CH_4]}{[H_2]\,[CO_2]}$

D. $K = \dfrac{4[H_2]\,[CO_2]}{2[H_2O]\,[CH_4]}$

For the reverse reaction where $CO_{2\,(g)} + 4H_{2\,(g)} \rightleftharpoons 2H_2O_{\,(g)} + CH_{4\,(g)}$ the expression for the equilibrium constant is:

$K = [H_2O]^2\,[CH_4] / [H_2]^4\,[CO_2]$

**Question 19**

Lithium-ion cells are excellent power sources for high-drain devices such as portable computers and mobile phones. These consist of an anode of lithium metal absorbed into graphite, a solid metal oxide cathode such as $CoO_2$, and a polymer electrolyte containing a dissolved metal salt. Which of the following reactions could not occur as the cell is discharging?

A. $Li \longrightarrow Li^+ + e^-$

B. $CoO_2 + Li^+ + e^- \longrightarrow LiCoO_2$

C. $Li + CoO_2 \longrightarrow LiCoO_2$

**D.** $\mathbf{LiCoO_2 \longrightarrow Li + CoO_2}$ (oxidation number decrease for both $Li^+$ and $CoO_2$ not possible)

If the cell is discharging then Li metal is oxidised to Lithium ions

| | | | |
|---|---|---|---|
| The positive (cathode) electrode half reaction is: | $CoO_2 + Li^+ + e^-$ | $\rightleftharpoons$ | $LiCoO_2$ |
| The negative (anode) electrode half reaction for the graphite is: | $Li$ | $\rightleftharpoons$ | $Li^+ + e^-$ |
| The full reaction (left: charged, right: discharged) being: | $Li + CoO_2$ | $\rightleftharpoons$ | $LiCoO_2$ |

**Question 20**

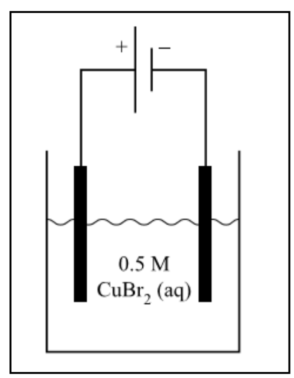
If the electrolytic cell shown here is operating at 25$^0$C and 1 atm pressure, an observer of the cell would see:

A. no reaction at all because the process is endothermic

B. a colourless gas at the cathode and a metallic coating on the anode

***C. a coloured liquid at the anode and a metallic coating on the cathode***

D. a colourless gas at the anode and a coloured liquid at the cathode




| | |
|---|---|
| Anode: | $2Br^-_{(aq)} \rightleftharpoons Br_{2\,(l)} + 2e^-$ (brown liquid) |
| Cathode: | $Cu^{2+}_{(aq} + + 2e^- \rightleftharpoons Cu_{(s)}$ (metallic solid) |

**Question 21**

With reference to the Electrochemical Series, which of the following compounds would have the same product at the anodes but a different product at the cathodes when comparing the electrolysis of its molten state with the electrolysis of the compound in a 1.0 M aqueous solution?

A. Sodium fluoride
B. Zinc chloride
C. Lead iodide
***D. Potassium bromide***

$2Br^-_{(aq)}$ is the strongest reductant whether in a molten or aqueous state so that

$$2Br^-_{(aq)} \rightleftharpoons Br_{2\,(l)} + 2e^-$$

Whereas $H_2O$ is a stronger oxidant than $K^+_{(aq)}$ so a molten state is needed to enable $K^+_{(aq)}$ to be reduced at the cathode

**Question 22**

A sample of argon gas occupies 48 L at 15°C and 720 mmHg. If the sample is heated to 30°C and the volume drops to 24 L, the new pressure will be closest to

***A. 200 kPa***
B. 300 kPa
C. 2000 kPa
D. 3000 kPa

$P_1 \times V_1/T_1 = P_2 \times V_2/T_2$ thus $\mathbf{P_2} = P_1 \times V_1/T_1 \times T_2/V_2$

= (720/760 x 101.325) kPa x 48 L / (273 + 15)K x (273 + 30)K / 24 L

= 202 kPa

**Question 23**

Which of the following compounds contains the highest percentage by mass of oxygen?

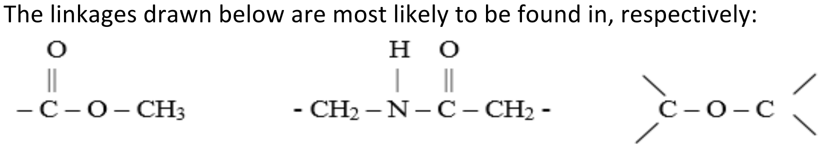
A. Butyl propanoate
B. 1-butanol
***C. Butanoic acid***
D. 1-aminobutane

The molecular or empirical formula of each compound can be used to show:

| | |
|---|---|
| Butyl propanoate | 32 g / 130 $gmol^{-1}$ x 100/1 = 24.6% |
| 1-butanol | 16 g / 74 $gmol^{-1}$ x 100/1 = 21.6% |
| Butanoic acid | 32 g / 88 $gmol^{-1}$ x 100/1 = **36.4%** |
| 1-aminobutane | No oxygen in molecule |

**Question 24**

The linkages drawn below are most likely to be found in, respectively:



***A. biodiesel, protein and carbohydrate***
B. lipid, protein and glucose
C. fatty acid, amino acid and polysaccharide
D. lipid, protein and carbohydrate

Biodiesel is an ester formed from the reaction of methanol and a fatty acid. Proteins have a - NH – CO- bond and carbohydrates have an ether bond C – O – C

**Question 25**

The reaction between glucose and fructose to form the disaccharide sucrose is best described as

***A. a condensation reaction with the formation of an ether linkage.***
B. a hydrolysis reaction with the formation of an ether linkage.
C. a condensation reaction with the formation of an ester linkage.
D. a hydrolysis reaction with the formation of an ester linkage.

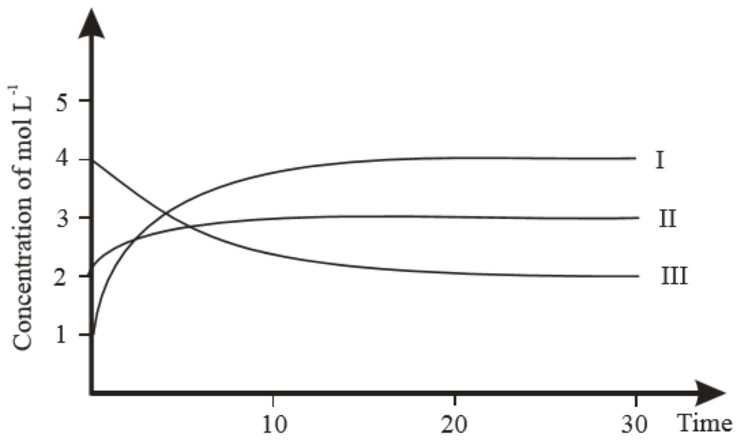
**Question 26**

Vitamins C and E are both essential vitamins. While the human body requires regular doses of vitamin C for good health, you can consume vitamin E less frequently. The reason for this is:

A. Vitamin C is essential but vitamin E can be produced by humans
***B. Vitamin C is water soluble but vitamin E is fat soluble***
C. Vitamin C is usually stored in fatty tissue and thus unavailable for metabolism by the human body
D. Vitamin E can be stored in the blood due to its solubility in water

**Question 27**

These graphs below show the concentrations for a mixture of gases, X, Y and Z which react and come to equilibrium according to the equation: $Y_{(g)} + 3Z_{(g)} \rightleftharpoons 2X_{(g)}$




Which of the graphs, I, II or III best represents the change in concentration of Y?

***A. I***

B. II

C. III

D. Cannot be determined on the basis of the information given.

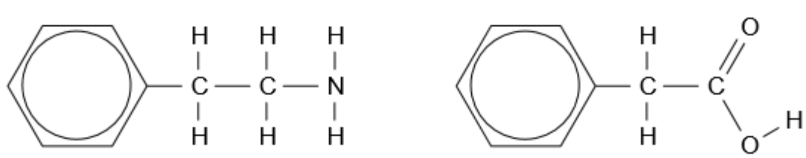
For the reaction $Y_{(g)} + 3Z_{(g)} \rightleftharpoons 2X_{(g)}$ reaching equilibrium, the rate of consumption or production of Z (hence II) must be 3 times greater than the rate of consumption or production of Y (hence I). Thus for the reverse reaction,

| | | |
|---|---|---|
| $2X_{(g)}$ $\rightleftharpoons$ | $Y_{(g)}$ + | $3Z_{(g)}$ |
| (III) | (I) | (II) |
| [decrease] | [increase] | [increase] |

Thus production of Y is at 1/3 the rate of Z as per the comparative rate shown on the graph

**Question 28**

Phenylethylamine is a substance found in the human brain. A person in love has high levels of this chemical. A person with depression, however, has had much of their phenyethylamine converted to phenylacetic acid. The structures of both molecules are shown below.



phenylethylamine phenylacetic acid

The conversion of phenylethylamine to phenylacetic acid occurs in two steps. Possible reagents causing these steps might be:

***A. NaOH then $Cr_2O_7^{2-}/H^+_{(aq)}$***

B. $Cr_2O_7^{2-}$ then NaOH

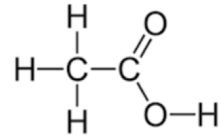
C. $Cl_2$ then NaOH

D. NaOH then $NH_3$

Carboxylic acids are formed most commonly from alkanol molecules. The NaOH can replace the $NH_2$ group with an –OH. The $Cr_2O_7^{2-}/H^+_{(aq)}$ converts the alkanol to a carboxylic acid.

**Question 29**

The ethanoic acid molecule shown here will have:



| | $^{1}$H NMR high resolution | Infrared spectrum $cm^{-1}$ | Mass spectrum |
|---|---|---|---|
| A. | 1 peak | 2 peaks | 3 peaks |
| B. | 2 peaks with no splits | includes a peak at 3000 but not 1700 | A base peak at 60 |
| ***C.*** | ***2 peaks with no splits*** | ***includes a peak at 3000 and at 1700*** | ***includes a peak at 15 and at 45*** |
| D. | 2 peaks, one a quartet and the other not split | includes a peak at 3000 and at 1700 | includes a peak at 15 and at 29 |

This molecule has 2 different hydrogen environments, hence 2 NMR peaks. There is no splitting of these peaks as there are no neighbouring hydrogen atoms. The C=O and the O – H both give IR peaks, one at 3000 and the other 1700. The mass spectrum has a peak at 15 due to $CH3^+$ and a peak at 45 due to $COOH^+$

**Question 30**

A 100 mL solution of glucose, $C_6H_{12}O_6$, has a concentration of 75.0 g $L^{-1}$. The number of glucose molecules in the solution is:

A. 0.0417

B. 0.417

***C. $2.51 \times 10^{22}$***

D. $2.51 \times 10^{23}$

1. The mass of glucose in the 100 mL solution: $m(C_6H_{12}O_6)$ = 0 .75 x 100/1000 × = 7.50 g
2. No. mol, of glucose molecules in the solution: $n(C_6H_{12}O_6)$ = m / M
   = 7.5g / 180 $gmol^{-1}$
   = 0.0417 mol
3. No. glucose molecules in the solution: n × NA = $0.0417 \times 6.02 \times 10^{23}$
   = $2.51 \times 10^{22}$ molecules

# Section B

**Question 1**

a. $K = [Fe(NCS)^{2+}] / [Fe^{3+}] [SCN^-]$

b. i. $V_{(total)} = 4.00 + 2.00 = 6.00$ mL
$n(Fe^{3+}) = c \times V = 2.00 \times 10^{-3} \times (4.00/1000) = 8.00 \times 10^{-6}$ mol
initial $[Fe^{3+}] = n / V = 8.00 \times 10^{-6} / (6.00/1000) = 1.33 \times 10^{-3}$ M

$n(SCN^-) = c \times V = 2.00 \times 10^{-3} \times (2.00/1000) = 4.00 \times 10^{-6}$ mol
initial $[SCN^-] = n / V = 4.00 \times 10\text{-}6 / (6.00/1000) = 6.67 \times 10^{-4}$ M

ii. The reaction is 1:1. Thus at equilibrium

$[Fe(NCS)^{2+}] = 7.87 \times 10^{-5}$ M
$[Fe^{3+}$, equilibrium$] = [Fe^{3+}$, initially$] - [Fe(NCS)^{2+}] = 1.33 \times 10^{-3} – 7.87 \times 10^{-5} = 1.25 \times 10^{-3}$ M
$[SCN^-$, equilibrium$] = [SCN^-$, initially$] - [Fe(NCS)^{2+}] = 6.67 \times 10^{-4} – 7.87 \times 10^{-5} = 5.88 \times 10^{-4}$ M

iii. As $K = [Fe(NCS)^{2+}] / [Fe^{3+}] [SCN^-]$
$= 7.87 \times 10^{-5} / (1.25 \times 10^{-3}) \times (5.88 \times 10^{-4})$
$= 107\ M^{-1}$

c. i. Changing the temperature of an equilibrium sample and observing/determining how the position of equilibrium shifts will determine the thermochemical nature of the reaction. This could be done experimentally by either heating or cooling a sample of the equilibrium mixture and comparing its colour changes.

ii. If the forward reaction were exothermic, then Le Chatelier's Principle states that increasing the temperature would cause the position of equilibrium to shift to the left, favouring the reverse reaction. This would result in the colour of the mixture becoming lighter when it re-establishes its equilibrium at the higher temperature. Conversely, cooling would result in the position of equilibrium shifting to the right, resulting in a darker coloured solution when equilibrium re-establishes.

iii. If the forward reaction were endothermic, then Le Chatelier's Principle states that increasing the temperature would cause the position of equilibrium to shift to the right, favouring the forward reaction. This would result in the colour of the mixture becoming darker when it re-establishes its equilibrium at the higher temperature. Conversely, cooling would result in the position of equilibrium shifting to the left, resulting in a lighter coloured solution when equilibrium re-establishes.

**Question 2**

a. $E = c \times m(H_2O) \times \Delta T = 4.18 \times 200 \times (85.6 - 22.7) = 52{,}584$ J = 52.6 kJ

b. $m(C_3H_8O) = (125.62 - 122.89) = 2.73$ g therefore $n(C_3H_8O) = 2.73 / 60.0 = 0.0455$
Thus enthalpy of combustion = 52.8 / 0.0455 = - 1156 kJ $mol^{-1}$

c. % of chemical energy into water = (calculated enthalpy / theoretical enthalpy) × 100 = (1156 / 2016) × 100 = 57.3 %

d. Any 2 of:
- less heat loss to surroundings due to the insulated container
- more complete combustion of 1-propanol in pure oxygen
- an assumption that all heat has gone into the water only

**Question 3**

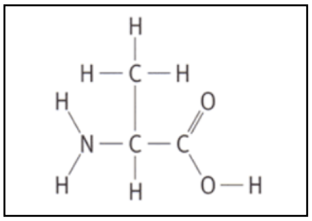
a. Reagent X = any source of $OH^-$ (NaOH, KOH, etc). Theoretically it could be $H_2O$ but reaction would be practically too slow

b. Compound **A**: $CH_2CH_2$ (ethene)
Compound **B:** $CH_3CH_2COOH$ (propanoic acid)
Compound **C:** $CH_3CH_2COOCH_2CH_3$

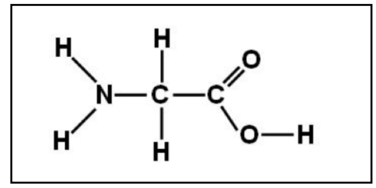
c. Compound **B** is butanoic acid and Compound C is ethyl propanoate (ethanol + propanoic acid = ethyl propanoate)

**Question 4**

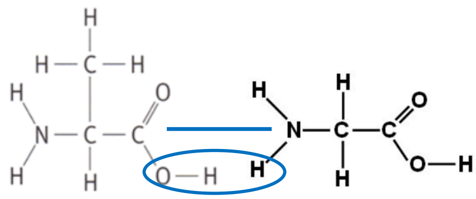
a. $C_3H_7NO_2$ is alanine



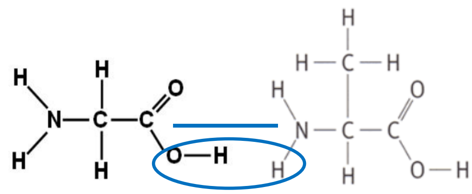
b. $C_2H_5NO_2$ is glycine



Either $NH_2CH(CH_3)CONHCH_2COOH$ (ALA-GLY) **OR** $NH_2CH_2CONHCH(CH_3)COOH$ (GLY-ALA)



**OR**



**Question 5**

This is an electrolytic reaction using inert electrodes and a molten electrolyte.

a. The positive electrode in an electrolytic cell is the anode and thus the site of oxidation. The only reductant present in the electrolyte is the chloride ions and are thus oxidised to chlorine gas. $2Cl^-_{(aq)} \rightleftharpoons Cl_{2\,(g)} + 2e^-$

b. The negative electrode will be the cathode and reduction will occur at this electrode. The only oxidant present in this cell is the magnesium ions which will be reduced to magnesium. $Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

c. If iron electrodes were used in place of the non-reactive platinum electrodes, then since iron is a reductant, it could be oxidised at the anode. Iron is a stronger reductant than chloride ions, so it would be oxidised at the positive electrode in place of the chloride ions. $Fe_{(s)} \rightleftharpoons Fe^{2+}_{(aq)} + 2e^-$
The reaction at the cathode will remain unchanged as the iron is not reduced.

d. An <u>aqueous</u> solution of magnesium chloride will introduce water into the electrolyte which may be either preferentially oxidised or reduced.

At the positive electrode (anode) the appropriate half-equations from the electrochemical series are:

$$Cl_{2\,(g)} + 2e^- \rightleftharpoons 2Cl^-_{(aq)} \qquad E^o = 1.36\ V$$
$$O_{2\,(g)} + 4H^+_{(aq)} + 4e^- \rightleftharpoons 2H_2O_{(l)} \qquad E^o = 1.23\ V$$

Since the electrolyte is a dilute aqueous solution, then oxygen will be produced because water is the stronger reductant.

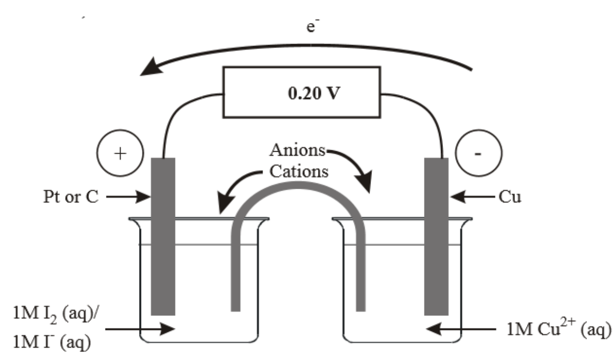
At the negative electrode (cathode) the appropriate half-equations from the electrochemical series are:

$$2H_2O_{(l)} + 2e^- \rightleftharpoons H_{2\,(g)} + 2OH^-_{(aq)} \qquad E^o = 0.83\ V$$
$$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)} \qquad E^o = 1.03\ V$$

Since the water is the stronger oxidant, it will be reduced in preference to the magnesium ions. The overall chemical equation for a cell containing a dilute aqueous magnesium chloride solution will be:

$$2H_2O_{(l)} \rightleftharpoons 2H_{2\,(g)} + O_{2\,(g)}$$

e.



The appropriate half-equations from the electrochemical series are:

$$I_{2(aq)} + 2e^- \rightleftharpoons 2I^-_{(aq)} \quad E^o = 1.03 \text{ V}$$
$$Cu^{2+}_{(aq)} + 2e^- \rightleftharpoons Cu_{(s)} \quad E^o = 0.34 \text{ V}$$

When these two half-cells are combined to produce a galvanic cell, the stronger oxidant (iodine) will be reduced at the cathode and the stronger reductant (copper) will be oxidised at the anode.

The electrolytes will be an aqueous solution containing iodine and iodide ions (potassium iodide) for the $I_{2(aq)}$ / $I^-_{(aq)}$ half-cell, and an aqueous solution containing copper(II) ions (copper(II) sulfate or nitrate) for the $Cu^{2+}_{(aq)}$ / $Cu_{(s)}$ half-cell.

The electrode for the $I_{2(aq)}$ / $I^-_{(aq)}$ half-cell would need to be a non-reactive electrode (platinum or graphite), while a copper metal electrode is required for the $Cu^{2+}_{(aq)}$ / $Cu_{(s)}$ half-cell.

Since the copper is being oxidised, this would be the anode, which would have a negative charge.

**Question 6**

a. 2 x $C_6H_{12}O_6$

b. $C_{12}H_{22}O_{11\,(s)} + 12O_{2\,(g)} \rightarrow 12CO_{2\,(g)} + 11H_2O_{\,(g)\text{ or }(l)}$

c. Since maltose contains 2 glucose molecules, 2 x 2816 = approximately 5632 $KJmol^{-1}$

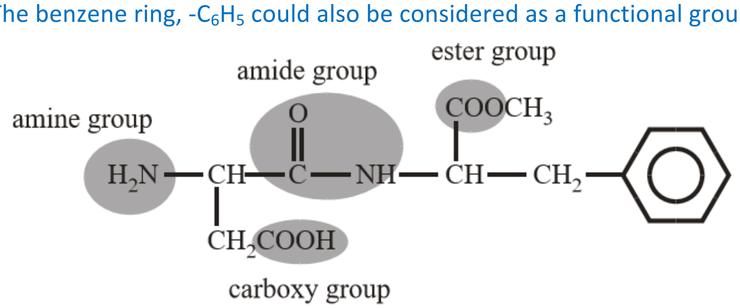
d. 3 (or any correct monounsaturated fatty acid formula)

e. $CH_3OH + C_{17}H_{35}COOH \rightarrow C_{17}H_{35}COOCH_3 + H_2O$

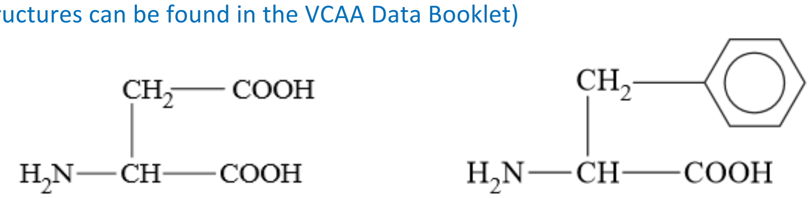
**Question 7**

a. A functional group is a group of atoms which determine the properties and reactions of an organic molecule. Those present on this molecule include:
   - Amine functional group, -NH2
   - Amide or peptide functional group, -CONH-
   - Ester functional group, -COO-
   - Carboxy functional group, -COOH

   The benzene ring, $-C_6H_5$ could also be considered as a functional group




b. Hydrolysis reactions break amide and ester linkages, therefore the two amino acids isolated would be aspartic acid and phenylalanine. (both structures can be found in the VCAA Data Booklet)




c. i. The catalytic activity of an enzyme is determined by its 3D shape and the key aspect of the protein structure that determines this is the tertiary structure.

   ii. The active site for an enzyme is determined by the 3D structure of the protein in a location where various amino acid residues can bond (via hydrogen bonding or ionic interactions) with the reacting molecule/substrate. Only reacting molecules with a very specific structure will be able to form these bonds at the active site. This bonding weakens specific bonds within the substrate, thus lowering the activation energy for the reaction. Once the bonds in the substrate are broken or rearranged and the new products are formed, the bonding to the active site weakens and the products are released. This is often referred to as a lock and key analogy.

**Question 8**

a. Platinum or graphite would be the appropriate choices (could be others but more expensive)

b. SLC: 25°C 1 atm, 1M $H^+_{(aq)}$

c. Cd must be the stronger reductant as $H^+$ has been reduced (so it must have been reduced by the Cd).

d. i. mole of $X^{2+}$ used = (1.00 – 0.725) × 0.1 = 0.0275 mol

ii. mole of electrons = 2654 / 96500 = 0.0274 mol. The ratio is therefore 1:1

iii. +3 ($X^{2+} \rightarrow X^{3+} + e^-$)

**Question 9**

a. At the anode oxidation will occur, therefore the hydrogen gas will be oxidised. Since the electrolyte is alkaline, hydroxide ions will be involved. From the Electrochemical Series, the appropriate half-equation will be:

$H_{2\,(g)} + 2OH^-_{(aq)} \rightleftharpoons 2H_2O_{(l)} + 2e^-$

b. $n(H_2) = V / Vm = 6.8\ L / 24.5\ L = 0.28$ mol

c. From the redox half-equation $n(e^-) = 2n(H_2) = 2 \times 0.28 = 0.56$ mol

$Q = n(e^-) \times F = 0.56 \times 96500 = 54000$ C

$I = Q / t = 54000 / (60 \times 60) = 15$ A

**Question 10**

a. i. The highest m/e value on the spectrum is 60.

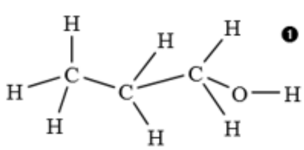
i. -OH in an alcohol can be deduced from the broad absorption band on the IR spectrum at around 3300 $cm^{-1}$.

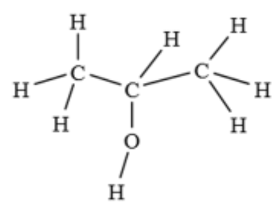
ii. 3 different $^1H$ environments can be deduced from sets of peaks at three distinct chemical shifts on the NMR spectrum.

b. $C_3H_8O$ is the molecular formula. Reference to common alcohols will identify the one with Mr = 60 as propanol.

Mr methanol ($CH_3OH$) = 32
Mr ethanol ($C_2H_5OH$) = 46
Mr propanol ($C_3H_7OH$) = 60

c.





d. The first structure – $CH_3CH_2CH_2OH$ – has 4 different $^1H$ environments and would be expected to show four distinct sets of peaks on its NMR spectrum. The second structure – $CH_3CHOHCH_3$ – has 3 different $^1H$ hydrogen environments (all 6 H on the two $CH_3$ are equivalent) and would be expected to show three distinct sets of peaks on its 1H NMR spectrum.

e. 2-propanol

f. i. The peak at m/e = 45 on the mass spectrum is due to the species $CH_3CHOH^+$ which is formed by the loss of a $CH_3$ during fragmentation. Since $CH_3$ has a relative mass of 15, a species with an m/e ratio 15 less than the molecule ion is identified by taking $CH_3$ off the molecule ion.

ii. On the $CH_3CHOHCH_3$ molecule, the H on the carbon atom on CHOH has a total of 6 equivalent neighbouring H atoms, 3 on each of the two $CH_3$. Hence its signal on the $^1H$ NMR spectrum is split into 6 + 1 = 7 smaller signals (septet).

**END OF SUGGESTED SOLUTIONS**