

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. 6×10^2 L at 273 K and 1 atm

$$V/V_M = 6 \times 10^2 / 22.4 \text{ (STP)} = 27 \text{ mole}$$

B. 6×10^{23} molecules

$$N_A = 1 \text{ mole}$$

C. 6×10^2 g

$$6 \times 10^2 \text{ g} / 32.0 \text{ g mol}^{-1} = 20 \text{ mole}$$

D. 6 mol

$$6 \text{ mole}$$

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. $\text{K}_2\text{Cr}_2\text{O}_7$ +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

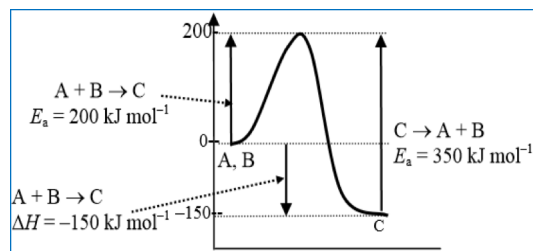
A. $+ 500 \text{ kJ mol}^{-1}$



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

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

D. $- 200 \text{ kJ mol}^{-1}$



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

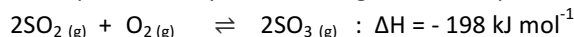
The electrolyte used to produce the major proportion of the chlorine gas commercially produced using electrolytic cells is

- 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: $2\text{Cl}^-_{(\text{aq})} \rightleftharpoons \text{Cl}_{2(\text{g})} + 2\text{e}^-$: Cathode reaction: $2\text{H}_2\text{O}_{(\text{l})} + 2\text{e}^- \rightleftharpoons \text{H}_{2(\text{g})} + 2\text{OH}^-_{(\text{aq})}$

Question 7

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



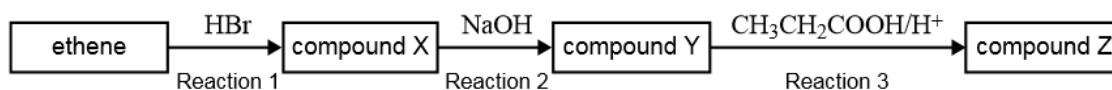
Adding more than the stoichiometric amount of oxygen to a sample of sulfur dioxide will:

- 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. $\text{CH}_2 = \text{CH}_2 \rightarrow \text{CH}_3\text{CH}_2\text{Br}$ (bromoethane/addition)

Reaction 2. $\text{CH}_3\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$ (ethanol/substitution)

Reaction 3. $\text{CH}_3\text{CH}_2\text{COOH} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3 + \text{H}_2\text{O}$
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

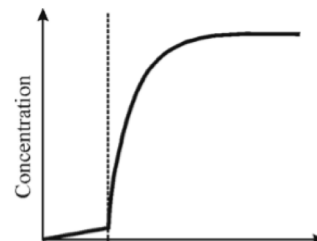
Question 10

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.

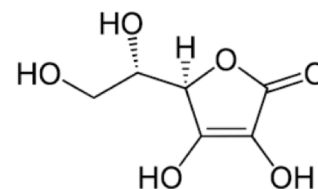


Following time t, the product concentration increases dramatically. This would require consumption of an increased amount of reactant. Adding a catalyst provides an alternative pathway for the reaction with a lower activation energy and can greatly increase the rate of reaction but not the yield of product.

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	$\text{O}_2 (\text{g}) + 4\text{H}^+_{(\text{aq})} + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O} (\text{l})$
B. oxygen	$\text{O}_2 (\text{g}) + 4\text{H}^+_{(\text{aq})} + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O} (\text{l})$
C. methanol	$\text{CH}_3\text{OH} (\text{g}) + \text{H}_2\text{O} (\text{l}) \longrightarrow \text{CO}_2 (\text{g}) + 6\text{H}^+_{(\text{aq})} + 6\text{e}^-$ Reductant causes reduction and is oxidised (e^- loss)
D. oxygen	$\text{CH}_3\text{OH} (\text{g}) + \text{H}_2\text{O} (\text{l}) \longrightarrow \text{CO}_2 (\text{g}) + 6\text{H}^+_{(\text{aq})} + 6\text{e}^-$

Question 13

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

- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3$**
- B. $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$
- D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3$

propanol + butanoic acid (+ production of 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: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$

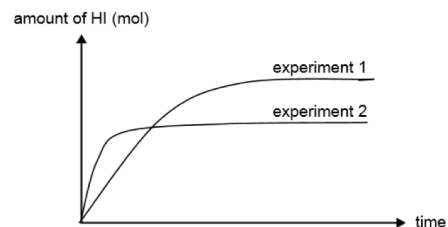
Two experiments investigating this reaction were conducted.

Experiment 1: quantities of $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ were placed in a sealed vessel and the reaction allowed to proceed at constant temperature.

Experiment 2: 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:



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

A. $K = \frac{[\text{H}_2\text{O}]^2 [\text{CH}_4]}{[\text{H}_2]^4 [\text{CO}_2]}$

B. $K = \frac{[\text{H}_2]^4 [\text{CO}_2]}{[\text{H}_2\text{O}]^2 [\text{CH}_4]}$

C. $K = \frac{[\text{H}_2\text{O}] [\text{CH}_4]}{[\text{H}_2] [\text{CO}_2]}$

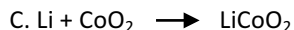
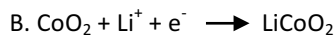
D. $K = \frac{4[\text{H}_2] [\text{CO}_2]}{2[\text{H}_2\text{O}] [\text{CH}_4]}$

For the reverse reaction where $\text{CO}_2(\text{g}) + 4\text{H}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g}) + \text{CH}_4(\text{g})$ the expression for the equilibrium constant is:

$$K = [\text{H}_2\text{O}]^2 [\text{CH}_4] / [\text{H}_2]^4 [\text{CO}_2]$$

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**?



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

The positive (cathode) electrode half reaction is:



The negative (anode) electrode half reaction for the graphite is:



The full reaction (left: charged, right: discharged) being:



Question 20

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

A. no reaction at all because the process is endothermic

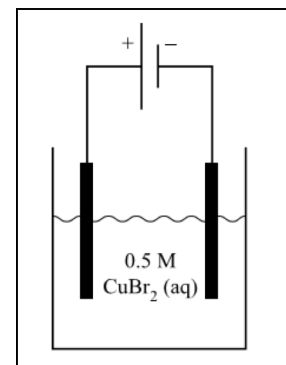
B. a colourless gas at the cathode and a metallic coating on the anode

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: $2\text{Br}^-(\text{aq}) \rightleftharpoons \text{Br}_2(\text{l}) + 2\text{e}^-$ (brown liquid)

Cathode: $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$ (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**

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



Whereas H_2O is a stronger oxidant than $\text{K}^+_{(\text{aq})}$ so a molten state is needed to enable $\text{K}^+_{(\text{aq})}$ 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

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

$$= (720/760 \times 101.325) \text{ kPa} \times 48 \text{ L} / (273 + 15) \text{ K} \times (273 + 30) \text{ K} / 24 \text{ L} \\ = 202 \text{ kPa}$$

Question 23

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

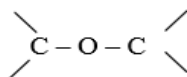
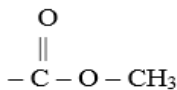
- A. Butyl propanoate
- B. 1-butanol
- C. Butanoic acid**
- D. 1-aminobutane

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

Butyl propanoate	$32 \text{ g} / 130 \text{ g mol}^{-1} \times 100/1 = 24.6\%$
1-butanol	$16 \text{ g} / 74 \text{ g mol}^{-1} \times 100/1 = 21.6\%$
Butanoic acid	$32 \text{ g} / 88 \text{ g mol}^{-1} \times 100/1 = \mathbf{36.4\%}$
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 $-\text{NH}-\text{CO}-$ bond and carbohydrates have an ether bond $\text{C}-\text{O}-\text{C}$

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.

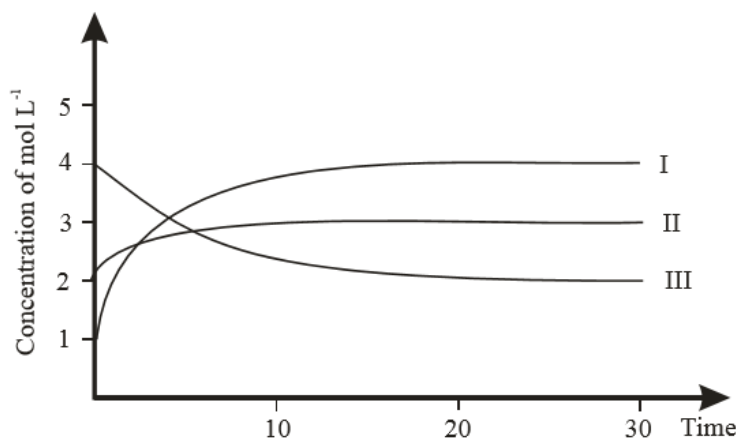
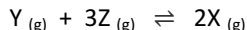
Question 26

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

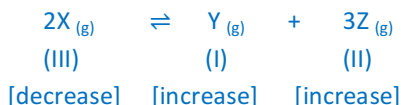
These graphs below show the concentrations for a mixture of gases, X, Y and Z which react and come to equilibrium according to the equation:



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.

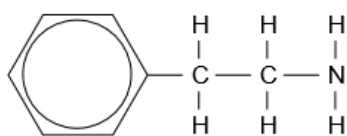
For the reaction $Y_{(g)} + 3Z_{(g)} \rightleftharpoons 2X_{(g)}$ reaching equilibrium, the rate of consumption or production of Z (hence II) must be 3 times greater than the rate of consumption or production of Y (hence I). Thus for the reverse reaction,



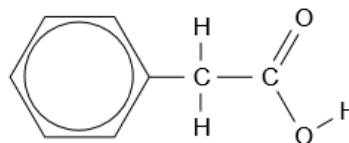
Thus production of Y is at 1/3 the rate of Z as per the comparative rate shown on the graph

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 phenylethylamine converted to phenylacetic acid. The structures of both molecules are shown below.



phenylethylamine



phenylacetic acid

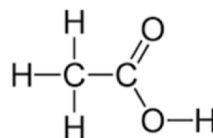
The conversion of phenylethylamine to phenylacetic acid occurs in two steps. Possible reagents causing these steps might be:

- A. NaOH then $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+_{(aq)}$
- B. $\text{Cr}_2\text{O}_7^{2-}$ 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 $-\text{OH}$. The $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+_{(aq)}$ 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, C₆H₁₂O₆, 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. 2.51×10^{22}
 D. 2.51×10^{23}

- | | |
|---|--|
| 1. The mass of glucose in the 100 mL solution: | $m(\text{C}_6\text{H}_{12}\text{O}_6) = 0.75 \times 100/1000 \times = 7.50 \text{ g}$ |
| 2. No. mol, of glucose molecules in the solution: | $n(\text{C}_6\text{H}_{12}\text{O}_6) = m / M$
$= 7.5\text{g} / 180 \text{ g mol}^{-1}$
$= 0.0417 \text{ mol}$ |
| 3. No. glucose molecules in the solution: | $n \times N_A = 0.0417 \times 6.02 \times 10^{23}$
$= 2.51 \times 10^{22} \text{ molecules}$ |

Section B

Question 1

- a. $K = \frac{[\text{Fe}(\text{NCS})^{2+}]}{[\text{Fe}^{3+}][\text{SCN}^-]}$
- b. i. $V_{\text{(total)}} = 4.00 + 2.00 = 6.00 \text{ mL}$
 $n(\text{Fe}^{3+}) = c \times V = 2.00 \times 10^{-3} \times (4.00/1000) = 8.00 \times 10^{-6} \text{ mol}$
 $\text{initial } [\text{Fe}^{3+}] = n / V = 8.00 \times 10^{-6} / (6.00/1000) = 1.33 \times 10^{-3} \text{ M}$

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

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

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

iii. As $K = \frac{[\text{Fe}(\text{NCS})^{2+}]}{[\text{Fe}^{3+}][\text{SCN}^-]}$

$$= 7.87 \times 10^{-5} / (1.25 \times 10^{-3}) \times (5.88 \times 10^{-4})$$
$$= 107 \text{ M}^{-1}$$

- 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

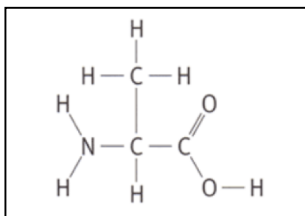
- a. $E = c \times m(\text{H}_2\text{O}) \times \Delta T = 4.18 \times 200 \times (85.6 - 22.7) = 52,584 \text{ J} = 52.6 \text{ kJ}$
- b. $m(\text{C}_3\text{H}_8\text{O}) = (125.62 - 122.89) = 2.73 \text{ g}$ therefore $n(\text{C}_3\text{H}_8\text{O}) = 2.73 / 60.0 = 0.0455$
Thus enthalpy of combustion = $52.8 / 0.0455 = -1156 \text{ kJ mol}^{-1}$
- c. % of chemical energy into water = (calculated enthalpy / theoretical enthalpy) $\times 100 = (1156 / 2016) \times 100 = 57.3 \%$
- 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

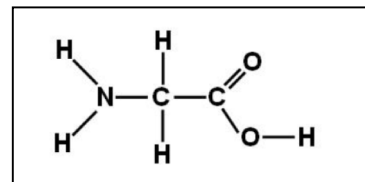
- a. Reagent X = any source of OH^- (NaOH, KOH, etc). Theoretically it could be H_2O but reaction would be practically too slow
- b. Compound A: CH_2CH_2 (ethene)
Compound B: $\text{CH}_3\text{CH}_2\text{COOH}$ (propanoic acid)
Compound C: $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$
- c. Compound B is butanoic acid and Compound C is ethyl propanoate (ethanol + propanoic acid = ethyl propanoate)

Question 4

a. $C_3H_7NO_2$ is alanine

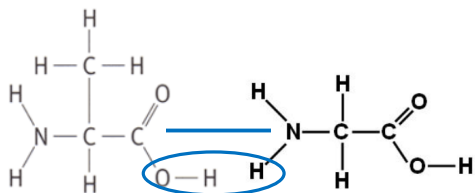


b. $C_2H_5NO_2$ is glycine

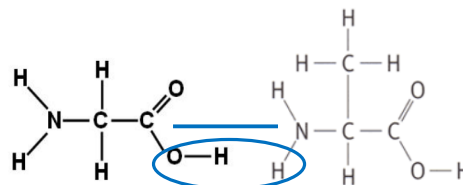


Either $NH_2CH(CH_3)CONHCH_2COOH$ (ALA-GLY) OR

$NH_2CH_2CONHCH(CH_3)COOH$ (GLY-ALA)



OR

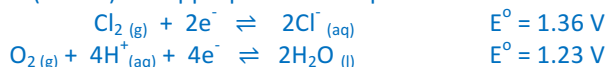


Question 5

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

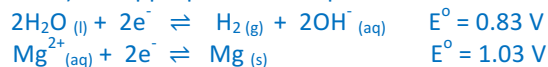
- The positive electrode in an electrolytic cell is the anode and thus the site of oxidation. The only reductant present in the electrolyte is the chloride ions and are thus oxidised to chlorine gas. $2Cl^-_{(aq)} \rightleftharpoons Cl_{2(g)} + 2e^-$
- The negative electrode will be the cathode and reduction will occur at this electrode. The only oxidant present in this cell is the magnesium ions which will be reduced to magnesium. $Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$
- 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.
- An aqueous 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:



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

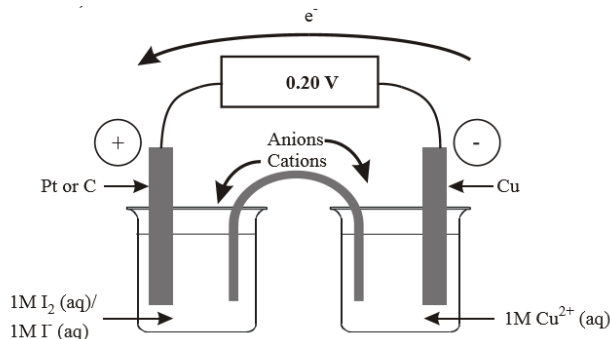
At the negative electrode (cathode) the appropriate half-equations from the electrochemical series are:



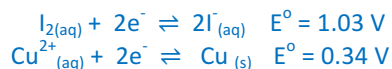
Since the water is the stronger oxidant, it will be reduced in preference to the magnesium ions. The overall chemical equation for a cell containing a dilute aqueous magnesium chloride solution will be:



e.



The appropriate half-equations from the electrochemical series are:



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 $\text{I}_{2(\text{aq})} / \text{I}^-_{(\text{aq})}$ half-cell, and an aqueous solution containing copper(II) ions (copper(II) sulfate or nitrate) for the $\text{Cu}^{2+}_{(\text{aq})} / \text{Cu}_{(\text{s})}$ half-cell.

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

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

Question 6

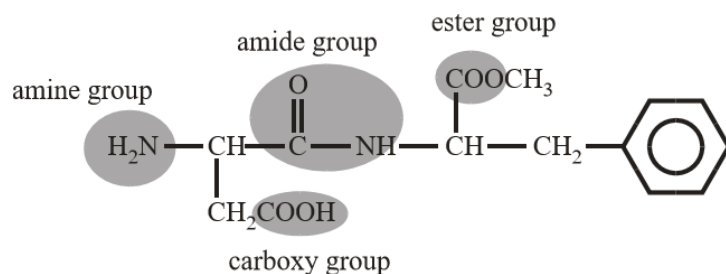
- a. $2 \times \text{C}_6\text{H}_{12}\text{O}_6$
- b. $\text{C}_{12}\text{H}_{22}\text{O}_{11(\text{s})} + 12\text{O}_{2(\text{g})} \rightarrow 12\text{CO}_{2(\text{g})} + 11\text{H}_2\text{O}_{(\text{g}) \text{ or } (\text{l})}$
- c. Since maltose contains 2 glucose molecules, $2 \times 2816 = \text{approximately } 5632 \text{ KJmol}^{-1}$
- d. 3 (or any correct monounsaturated fatty acid formula)
- e. $\text{CH}_3\text{OH} + \text{C}_{17}\text{H}_{35}\text{COOH} \rightarrow \text{C}_{17}\text{H}_{35}\text{COOCH}_3 + \text{H}_2\text{O}$

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, $-\text{NH}_2$
- Amide or peptide functional group, $-\text{CONH}-$
- Ester functional group, $-\text{COO}-$
- Carboxy functional group, $-\text{COOH}$

The benzene ring, $-\text{C}_6\text{H}_5$ 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)



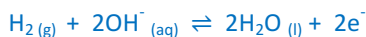
- c. i. The catalytic activity of an enzyme is determined by its 3D shape and the key aspect of the protein structure that determines this is the tertiary structure.
- ii. The active site for an enzyme is determined by the 3D structure of the protein in a location where various amino acid residues can 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

- Platinum or graphite would be the appropriate choices (could be others but more expensive)
- SLC: 25°C 1 atm, 1M H⁺_(aq)
- Cd must be the stronger reductant as H⁺ has been reduced (so it must have been reduced by the Cd).
- mole of X²⁺ used = (1.00 – 0.725) × 0.1 = 0.0275 mol
 - mole of electrons = 2654 / 96500 = 0.0274 mol. The ratio is therefore 1:1
 - +3 (X²⁺ → X³⁺ + e⁻)

Question 9

- 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:



- $n(\text{H}_2) = V / V_m = 6.8 \text{ L} / 24.5 \text{ L} = 0.28 \text{ mol}$
- From the redox half-equation $n(\text{e}^{-}) = 2n(\text{H}_2) = 2 \times 0.28 = 0.56 \text{ mol}$
 $Q = n(\text{e}^{-}) \times F = 0.56 \times 96500 = 54000 \text{ C}$
 $I = Q / t = 54000 / (60 \times 60) = 15 \text{ A}$

Question 10

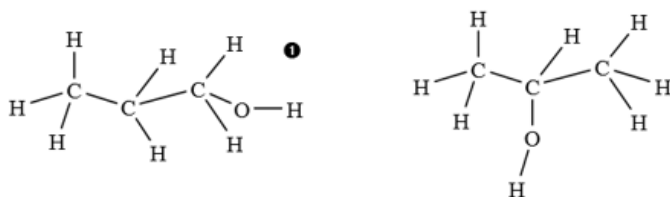
- The highest m/e value on the spectrum is 60.
 - OH in an alcohol can be deduced from the broad absorption band on the IR spectrum at around 3300 cm⁻¹.
 - 3 different ¹H environments can be deduced from sets of peaks at three distinct chemical shifts on the NMR spectrum.
- C₃H₈O is the molecular formula. Reference to common alcohols will identify the one with Mr = 60 as propanol.

Mr methanol (CH₃OH) = 32

Mr ethanol (C₂H₅OH) = 46

Mr propanol (C₃H₇OH) = 60

c.



- The first structure – CH₃CH₂CH₂OH – has 4 different ¹H environments and would be expected to show four distinct sets of peaks on its NMR spectrum. The second structure – CH₃CHOHCH₃ – has 3 different ¹H hydrogen environments (all 6 H on the two CH₃ are equivalent) and would be expected to show three distinct sets of peaks on its ¹H NMR spectrum.
- 2-propanol
- The peak at m/e = 45 on the mass spectrum is due to the species CH₃CHOH⁺ which is formed by the loss of a CH₃ during fragmentation. Since CH₃ has a relative mass of 15, a species with an m/e ratio 15 less than the molecule ion is identified by taking CH₃ off the molecule ion.
 - On the CH₃CHOHCH₃ molecule, the H on the carbon atom on CHOH has a total of 6 equivalent neighbouring H atoms, 3 on each of the two CH₃. Hence its signal on the ¹H NMR spectrum is split into 6 + 1 = 7 smaller signals (septet).

END OF SUGGESTED SOLUTIONS