Neap:

Trial Examination 2013

VCE Chemistry Units 3 & 4

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

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

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Question 1 **D**

The basis of infrared spectroscopy is the absorption of energy by molecules as their covalent bonds vibrate and rotate. NMR spectroscopy involves changes in the spin alignment of ^{13}C and ^{1}H placed in a strong magnetic field. In mass spectroscopy, charged particles are deflected by a combination of electric and magnetic fields. AAS involves absorption of light as electrons in metal atoms in the gaseous state gain energy and move to an excited state.

Question 2 **A**

The usual synthesis involves reacting salicylic acid with ethanoic anhydride ($C_4H_6O_3$) and producing ethanoic acid ($C_2H_4O_2$) as a by-product. **A** is the correct answer. Aspirin can be synthesised using ethanoic acid as a reactant, but water, not H_2O_2, is produced. Thus **B** is incorrect. For alternatives **C** and **D**, the tally of atoms is not correct between the reactants and products, and/or the compounds are not capable of participating in an esterification reaction.

Question 3 **B**

Acid–base titration could not be used as there will be unused salicylic acid in the reaction vessel, resulting in an incorrect equivalence point. Alternative I is not correct. Thin-layer chromatography is largely a qualitative technique and so could not be used to determine the amount of aspirin. Alternative II is not correct. Salicylic acid and aspirin will most likely absorb at different wavelengths and thus, using an appropriate calibration graph, the amount of aspirin could be determined. *$FeCl_3$ reacts with salicylic acid to form a purple compound which may be used in the spectroscopic analysis.* Alternative III could be used.

Question 4 **B**

$$n(Br_2) = \frac{m}{M} = \frac{120}{159.8} = 0.75 \text{ mol}$$

$$n(\text{acid}) : n(Br_2) = 0.75 : 0.75 = 1 : 1$$

(indicating the presence of one double C=C bond)

The acid formula, with 22 carbon atoms, is therefore $C_{21}H_{41}COOH$ or $C_{22}H_{42}O_2$

Question 5 **D**

The activity of the enzyme increases as the OH^- concentration increases up to pH 5, but decreases with higher OH^- concentration. **A** is not correct. At pH 5, $[OH^-]$ does not equal $[H^+]$ and thus **B** is incorrect. The tertiary structure of an enzyme controls the configuration of the active site. Changing the pH affects the tertiary structure and, thus, also the active site. **C** is incorrect and **D** is the required answer.

Question 6 **C**

Lowering the temperature of the experiment will decrease the energy of substrate molecules and the frequency of interaction with the enzyme. The rate of reaction will be lower, and thus a higher percentage of sucrose will remain unreacted. **C** is the correct answer.

Question 7 **D**

Decolourising the bromine suggests a double C=C bond (**C** is incorrect). Extended oxidation of an alkanol which fails to produce a carboxylic acid suggests a secondary alkanol (**A** is incorrect). Failure to react with Na_2CO_3 suggests that the compound does not contain a carboxyl group (**B** is incorrect). **D** shows the necessary features in the molecule.

Question 8 C

Reduction: O.N. of Cl changes from 0 in Cl_2 to –1 in HCl.

Oxidation: O.N. of Cl changes from 0 in Cl_2 to +1 in HOCl.

Question 9 C

The threonine moved halfway to the solvent front, i.e. 6 cm. The hydroxyproline therefore moved 8 cm (i.e. 6 + 2).

R_f (hydroxyproline) = $\frac{8}{12}$ = 0.67

Question 10 D

Methanamine is a weak base which will only partially ionise in water. A large percentage of the molecules remain unionised.

Question 11 D

The primary structure of DNA is the chain of nucleotides in each strand of nucleic acid. The secondary structure is the hydrogen bonding interactions between the polynucleotide strands in the DNA molecule. Thus both types of structures are depicted in the diagram. A nucleotide consists of a sugar, a nitrogenous base and a phosphate group. There are six nucleotides shown in the diagram and so **D** is the correct answer.

Question 12 B

As there are three hydrogen bonds, base 2 must be cytosine or guanine. According to the stated ratio, there are 8 base 2 for every 25 bases in the DNA molecule. So in 1000 bases, there will be 320 $\left(8 \times \frac{1000}{25}\right)$ base 2, i.e. 160 pairs of cytosine and guanine, and 680 base 1, i.e. 340 pairs of adenine and thymine. Thus for the 500 base pairs, A : T : G : C is 340 : 340 : 160 : 160.

Question 13 A

$$n(\text{propene}) = \frac{m}{M} = \frac{0.238}{42}\ \text{mol}$$

$$V(\text{propene}) = n \times Vm = \frac{0.238}{42} \times 22.4\ \text{L}$$

$$V(\text{butane}) = V(\text{propene}) = \frac{0.238}{42} \times 22.4\ \text{L}$$

$$n(\text{butane})\ \text{at SLC} = \frac{V}{Vm} = \frac{0.238}{42} \times \frac{22.4}{24.5} = 5.18 \times 10^{-3}\ \text{mol}$$

Question 14 C

$$m(\text{Cr}) = \frac{6.02}{100} \times 15.0\ \text{g}$$

$$n(\text{Cr}) = \frac{m}{M} = \frac{6.02}{100} \times \frac{15.0}{52.0}\ \text{mol}$$

$$c(\text{Cr}) = \frac{n}{V} = \frac{\left(\frac{6.02}{100} \times \frac{15.0}{52.0}\right)}{0.3000} = 0.0579\ \text{M}\ \text{(giving an absorbance close to 0.3)}$$

Question 15 B

Propanoic is a weak acid. In a 0.1 M solution, the H^+ concentration will be less than 0.1 M, and so the pH will be greater than 1. The graphs in **A** and **C** are incorrect. At the equivalence point of the titration, the presence of the propanoate ion, a weak base, gives a pH of greater than 7. The graphs in **B** and **D** both show this. The titre, the volume of NaOH needed to reach equivalence, will be around 13.3 mL ($\frac{0.1 \times 20.00}{0.150}$). Therefore **B**, not **D**, is correct.

Question 16 C

Alternative I is a fossil fuel source and is not renewable. Alternative II, powered by a renewable energy source, involves recycling of materials and is renewable. Alternative III (biogas) is currently used and provides a renewable source of the fuel.

Question 17 D

The reaction is endothermic, so it takes more energy to break the bonds in the reactants than the energy released when the products form. **A** is incorrect. The activation energy of the reverse reaction is $x + y - z$, so **B** is incorrect. Energy equivalent to $x + y - z$ is released as bonds form. **C** is incorrect. For the overall reaction, there is an absorption of energy equivalent to $z - x$, i.e. the magnitude of the heat of reaction is equal to $z - x$.

Question 18 D

Recharging a secondary cell involves connecting + to + and – to –, as the spontaneous reactions are being forced to reverse by application of a greater potential than the cell potential. **A** and **C** are incorrect. Oxidation occurs at the anode or negative electrode during discharge. **B** is incorrect. As the reactions are forced to reverse, the product of the spontaneous reaction must stay in contact with the electrodes and become the reactants of the recharge reaction. Thus **D** is correct and is the required answer.

Question 19 C

$$n(\text{CaCl}_2) = \frac{m}{M} = \frac{11.1}{111} = 0.100 \text{ mol}$$

$$\Delta T = 32.5°\text{C}$$

$$E = m \times c \times \Delta T = 60.0 \times 4.18 \times 32.5 \text{ J}$$

$$\text{heat of solution} = \frac{E}{n} = \frac{(60.0 \times 4.18 \times 32.5)}{0.100} = 81\ 510 \text{ J mol}^{-1} = 81.5 \text{ kJ mol}^{-1}$$

Question 20 A

To achieve Reaction I, the first reaction is reversed and the coefficients are doubled, so the ΔH becomes $2 \times +272$. The coefficients of the second reaction are tripled and so the ΔH becomes 3×-484. Thus ΔH for Reaction I $= +544 - 1452 = -908 \text{ kJ mol}^{-1}$.

Question 21 C

Pure water is always neutral irrespective of its pH, as $[H_3O^+] = [OH^-]$. Statements I and II are incorrect. The equilibrium constant increases as temperature increases. Thus the self-ionisation reaction is endothermic. The low value of the K_w at any temperature indicates that the position of equilibrium is heavily with the reactants. Statement III is correct. The pH of water at 0°C is 7.47 and at 25°C is 7. Statement IV is also correct.

Question 22 D

The predicted reaction does not occur because the rate of reaction under standard conditions is very slow. Neither statement I or II can be used to explain this. The K for the reaction would indicate that the position of equilibrium lies almost fully with the products, and thus is not relevant to explaining the lack of reaction. The ΔH is the difference between the heat of the products and the heat of the reactants and has no relevance to the rate of reaction.

Question 23 B

$$\text{Voltage} = E^0(\text{oxidant half-cell}) - E^0(\text{reductant half-cell}) = (+1.77) - (+0.68) = 1.09 \text{ V}$$

The oxidation number decreases in the reduction reaction. Reduction occurs at the cathode. **B** is the required answer.

Question 24 A

Adding a catalyst, increasing pressure (by decreasing volume) and increasing temperature all increase reaction rate (hence **B**, **C** and **D** are incorrect). Using air will decrease the concentration of the reactant, O_2, and hence will decrease reaction rate.

Question 25 C

$$n(\text{methyl palmitate}) = \frac{m}{M} = \frac{0.378}{270} \text{ mol}$$

$$\text{energy released on combustion} = \left(\frac{0.378}{270}\right) \times 1.07 \times 10^4 \text{ kJ}$$

$$\text{C.F.} = \frac{E}{\Delta T} = \frac{\left(\frac{0.378}{270}\right) \times 1.07 \times 10^4}{4.53} = 3.31 \text{ kJ °C}^{-1}$$

As this value is closest to 3.50 kJ $°C^{-1}$, the correct answer is **C**.

Question 26 B

For the calibration factor $\left(\frac{E}{\Delta T}\right)$ to be greater than the actual value, the temperature change was smaller than it should have been. In situation I, the temperature rise would be greater and thus $\left(\frac{E}{\Delta T}\right)$ becomes a smaller number. In situation II, the temperature rise would be smaller as more heat is lost without insulation. The C.F. would be greater.

Question 27 A

E^0_3 must be greater than E^0_1, as nitric acid and hydrochloric acid when mixed will react with platinum. E^0_2 must be greater than E^0_3 as nitric acid will not react with platinum. Thus the order (with the lowest first) is $E^0_1 < E^0_3 < E^0_2$. **A** is the required answer.

Question 28 B

The powdered form has a greater surface area than an equivalent mass of pellets and thus the rate of reaction would be expected to be greater. **B** is the correct answer. **A** and **D** refer to the energy difference between the products and reactants and the form of the reactants has no influence on this quantity. **A** and **D** are incorrect. Similarly, the equilibrium yield is not affected by how fast the products form and so **C** is not correct.

Question 29 A

Electrons do not move between the anode and cathode through the electrolyte. **B** is not correct. However, ions do move through the electrolyte and thus any separator must be porous to allow this movement. **C** is incorrect. **A** is correct. There is no indication that catalysis is necessary in this cell but, even if it was, a layer of catalyst which is isolated from most of the reactants would not be very effective. **D** is not correct.

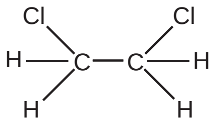
Question 30 A

B and **D** are not correct as MnO_2 is the oxidant and it will be reduced at the cathode, the positive electrode. **C** is incorrect as Zn is oxidised at the anode. At the cathode, OH^- ions are produced and the pH would rise. **A** is the correct answer.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1 (14 marks)

a.



1 mark

1, 2–dichloroethane 1 mark

b. *Either one of the following (parts* **i.** *and* **ii.***):*

i. increase temperature 1 mark

As it is an endothermic reaction, increasing the temperature will move the position to favour the products so as to partly oppose the temperature rise. 1 mark

ii. This would require a greater usage of energy which will be more costly than using a lower temperature. 1 mark

OR

i. lowering pressure 1 mark

As 1 mol of gaseous reactants produces 2 mol of gaseous products, lowering the pressure will shift the position of equilibrium to the products so as to partly oppose the change in pressure. 1 mark

ii. Lowering the pressure will lower the rate of reaction, resulting in a smaller amount of product available for commercial sale in a set time. 1 mark

iii. Recycle the heat so that the furnace for Reaction II could use the energy. 1 mark

c. *For example:*

Ethene is a cheaper raw material. Even though the production process is less efficient, it is more cost effective. 1 mark

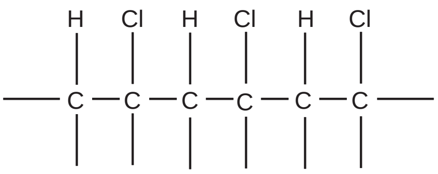
d. **i.** Using nitrogen minimises the risk of fire as it does not support combustion. 1 mark

ii. Standard samples of known concentration of pure chloroethene are run through the GC device in order to generate a calibration graph of peak area versus concentration. 1 mark

A sample of the gas from the void is run through the GC device and the peak at the retention time of chloroethene is considered. 1 mark

Peak area is determined, and thus its concentration is found using the calibration graph. 1 mark

e. **i.**



1 mark

ii. At very high temperatures, all of the bonds in the material are likely to be broken and gaseous products formed. 1 mark

At high temperatures, complete reaction of the waste produces simple molecules such as carbon dioxide and water. 1 mark

Question 2 (10 marks)

a. **i.** $C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$ 1 mark

ii. $MnO_4^-(aq)$ is a stronger oxidant than $CO_2(g)$ and $C_2O_4^{2-}(aq)$ is a stronger reductant than $Mn^{2+}(aq)$. 1 mark

When a stronger oxidant is mixed with a stronger reductant, a chemical reaction is likely to occur under standard conditions. 1 mark

iii. The EC series indicates nothing about the rate of reaction and this reaction could be slow in the conditions which are used. 1 mark

b. **i.** $n(MnO_4^-) = c \times V = 0.1575 \times 0.01428 = 2.2491 \times 10^{-3}$mol 1 mark

$n(C_2O_4^{2-}) = \frac{5}{2} \times n(MnO_4^-)$ mol 1 mark

$c(C_2O_4^{2-}) = \frac{n}{V} = \frac{\left(\frac{5}{2} \times 2.2491 \times 10^{-3}\right)}{0.02500} = 0.2249$ M 1 mark

ii.

Piece of glassware left wet with water	**Effect on calculated concentration of acidified $MnO_4^-(aq)$ solution**		
	Higher than actual value	**Same as actual value**	**Lower than actual value**
25.00 mL pipette	*		
burette			*
conical flask		*	

3 marks

Question 3 (13 marks)

a. **i.** $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ 1 mark

ii. $Al(s) + 3OH^-(aq) \rightarrow Al(OH)_3(s) + 3e^-$ 1 mark

b. porous 1 mark

c. **i.** A continuous stream of the reactant oxygen is supplied to the cell. 1 mark

ii. When all of the reactant aluminium is used up, the cell will not produce any more electrical energy. The cell cannot be recharged. 1 mark

d. The cell reaction occurs on the surface of the electrodes. 1 mark

If the reactants are prevented from being in contact with the surface by the gel, the efficiency of the cell in producing electrical energy will decrease. 1 mark

e. This is not a viable proposal as aluminium metal cannot be produced from aqueous solutions of aluminium ions by electrolysis. 1 mark

Water is a stronger oxidant than aluminium ions and will be reduced preferentially at the cathode. 1 mark

f. $n(\mathrm{e}^-) = \dfrac{\mathrm{I} \times t}{F} = \dfrac{120\ 000 \times 10 \times 60 \times 60}{96\ 500} = 44\ 767$ mol 1 mark

$n(\mathrm{Al}) = \dfrac{1}{3} \times n(\mathrm{e}^-) = \dfrac{44\ 767}{3}$ mol 1 mark

$n(\mathrm{CO_2}) = \dfrac{3}{4} \times n(\mathrm{Al}) = \dfrac{3}{4} \times \dfrac{44\ 767}{3}$ mol 1 mark

$V = \dfrac{nRT}{p} = \dfrac{\left(\dfrac{3}{4} \times \dfrac{44\ 767}{3} \times 8.31 \times 293\right)}{100} = 2.73 \times 10^5$ L 1 mark

Question 4 (11 marks)

a. Diethyl ether molecules show little polarity and are thus held to each other mainly by weak dispersion forces. These are disrupted at low temperatures. 1 mark

Propanoic acid has a carboxyl group and 1-butanol has a hydroxyl group in each molecule, and so hydrogen bonds occur between molecules in these compounds. Hydrogen bonds are stronger than dispersions forces, and so propanoic acid and butanol have higher boiling points than diethyl ether. 1 mark

b. **i.** $\mathrm{CH_2OH^+}$ 1 mark

ii. Peak at m/z = 56 labelled A *(removal of* H_2O *∴ 74 – 18 = 56)* 1 mark

c.

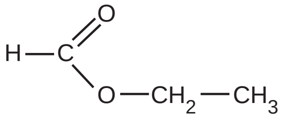
Chemical shift (ppm)	Relative peak area	Peak splitting
1.1	3	3
2.4	2	4
11.8	1	1

3 marks

d. The spectrum is for propanoic acid as there is a significant trough at 1670 to 1750 $\mathrm{cm^{-1}}$ due to the C=O group in the acid. 1 mark

The O–H group in alcohols produces at trough at 3200 to 3550 $\mathrm{cm^{-1}}$ but this is not present here. The trough at 2500 to 3300 $\mathrm{cm^{-1}}$ due to the O–H group in acids is present. 1 mark

e. **i.**



1 mark

ii. methanoic acid 1 mark

Question 5 (13 marks)

a. **i.** D, E, F — 1 mark

ii. $n(\text{Al}(C_9H_6NO)_3)$ in 100.0 mL of water $= \frac{m}{M} = \frac{25.0 \times 10^{-3}}{459} = 5.45 \times 10^{-5}$ mol — 1 mark

iii. $n(\text{Al}(C_9H_6NO)_3)$ in 500 L of water $= \frac{0.0250}{459} \times \frac{500}{0.100}$ — 1 mark

$n(C_9H_7NO) = 3 \times n(\text{Al}(C_9H_6NO)_3)$ — 1 mark

$$V(C_9H_7NO) = \frac{n}{c} = \frac{\left(3 \times \frac{0.0250}{459} \times \frac{500}{0.100}\right)}{0.10} = 8.2 \text{ L}$$ 1 mark

iv.

What is the purpose of washing each precipitate in step III?	**To remove adsorbed ions which are not part of the precipitate**
What steps should be taken to ensure that the mass of each precipitate is accurate?	**Dry and weigh the precipitate until constant mass is reached.**

2 marks

v.

0.00516 M 8-hydroxyquinoline solution was used	
150.0 mL samples of contaminated water were used	✓
Each precipitate was washed several more times than originally	

1 mark

b. **i.** $C_9H_7NO(aq) + H_2O(l) \rightleftharpoons C_9H_6NO^-(aq) + H_3O^+(aq)$ — 1 mark

ii. $K_a = \frac{[C_9H_6NO^-][H_3O^+]}{C_9H_7NO}$ — 1 mark

iii. $[C_9H_6NO^-] = [H_3O^+]$

and $[C_9H_7NO]\text{eq.} = [C_9H_7NO]_i$ because the extent of ionisation is very small.

$[H_3O^+]^2 = 1.58 \times 10^{-9} \times 0.30$ — 1 mark

$[H_3O^+] = 2.18 \times 10^{-5}$ M — 1 mark

$\text{pH} = -\log[H_3O^+] = 4.7$ — 1 mark

Question 6 (13 marks)

a. $C_6H_{12}O_6(aq) \rightarrow 2C_2H_6O(aq) + 2CO_2(g)$ 2 marks

1 mark for reactants and products
1 mark for states and balancing

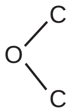
b. **i.** On the diagram, any of the peaks 1, 2 or 3 should be lower OR any of the peaks 4, 5, 6 or 7 should be higher. 1 mark

ii.

Increasing the temperature of the HPLC analysis will not change the retention times of the components.	
Doubling the volume of mixture analysed by HPLC will double the retention time of the components.	
Using smaller stationary phase particles will increase the retention times of the components.	✓
The component most strongly adsorbed to the stationary phase is ethanol.	✓
Using a mobile phase of a different polarity will have no effect on the retention times.	
Once a component is adsorbed strongly to the column, no desorption will occur.	

2 marks

iii. ether (or glycosidic) linkage. 1 mark



1 mark

iv. $C_{12}H_{22}O_{11}$ 1 mark

c. **i.** molar enthalpy of octane = –5464 kJ. Each mol of C_8H_{18} produces 8 mol of CO_2. 1 mark

$$\frac{\text{mole of } CO_2}{\text{kJ of energy}} = \frac{8}{5464} = 1.46 \times 10^{-3} \text{ mol kJ}^{-1}$$ 1 mark

molar enthalpy of ethanol = –1364 kJ. Each mol of C_2H_5OH produces 2 mol CO_2.

$$\frac{\text{mole of } CO_2}{\text{kJ of energy}} = \frac{2}{1364} = 1.47 \times 10^{-3} \text{ mol kJ}^{-1}$$ (almost the same as octane) 1 mark

ii. The carbon dioxide from octane is from a fossil fuel and contributes to increasing concentrations of atmospheric CO_2, a cause of the enhanced greenhouse effect. 1 mark

The carbon dioxide gas from a biochemical fuel is not adding to the amount of atmospheric CO_2 because a similar quantity was taken from the atmosphere and used in photosynthesis by the plant material which is eventually used to make the biofuel. 1 mark

Question 7 (10 marks)

a. **i.** *At the cathode or negative electrode, reduction occurs. The oxidants present in order of decreasing oxidising strength are* Pb^{2+}*,* Ni^{2+}*, water and* Mg^{2+}*.*

Pb^{2+} will be reduced first and coat the electrode with lead until all of these ions are used.

$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$ 1 mark

Ni^{2+} ions will be reduced next and coat the lead-plated electrode with nickel.

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(aq)$ 1 mark

Water will then be reduced, and thus bubbles of hydrogen gas will evolve at the cathode.

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ 1 mark

Mg^{2+} will not be reduced as water is a stronger oxidant. 1 mark

Note: Cu^{2+} *ions from the oxidation of the anode may also be reduced at the cathode but its concentration will be very low in the initial stages.*

ii. *At the anode or positive electrode, oxidation occurs. The reductants present in order of decreasing reducing strength are copper and water.*

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ 1 mark

b. **i.** The experiment should be designed so that, when comparing two different results, the conditions under which the results were obtained vary by one factor only. 1 mark

Cell C and Cell D have been designed well in that the only factor different between them is the concentration of the electrolyte and thus any difference in the results will be due to this factor. 1 mark

No other valid comparison of results can be made for the other cells because at least two factors have been changed and thus the difference in any results cannot be assigned to a single factor. 1 mark

ii. *For example, any two of:*

- The conditions for Cell A and Cell B should be the same surface area of the electrode and concentration of the electrolyte, with only the temperature different.
- The conditions for Cell B and Cell C should have identical temperature and electrolyte concentration, but different electrode surface area.
- To ensure a greater validity of data, each set of experiments should also be repeated numerous times so that averaging of the data is possible.

2 marks

Question 8 (11 marks)

a. The radioactive hydrogen will participate in the equilibrium, i.e. it will react with iodine at the same rate that HI will be broken down. 1 mark

Radioactive HI should be detected as the forward and reverse reactions will continue even though there is no evident concentration change. 1 mark

b. $K = \dfrac{[HI]^2}{[H_2][I_2]}$ 1 mark

$= \dfrac{(0.040)^2}{(0.090)(0.060)}$ 1 mark

$= 0.30$ 1 mark

c. As the gaseous concentrations decreased, the volume of the equilibrium container was increased. 1 mark

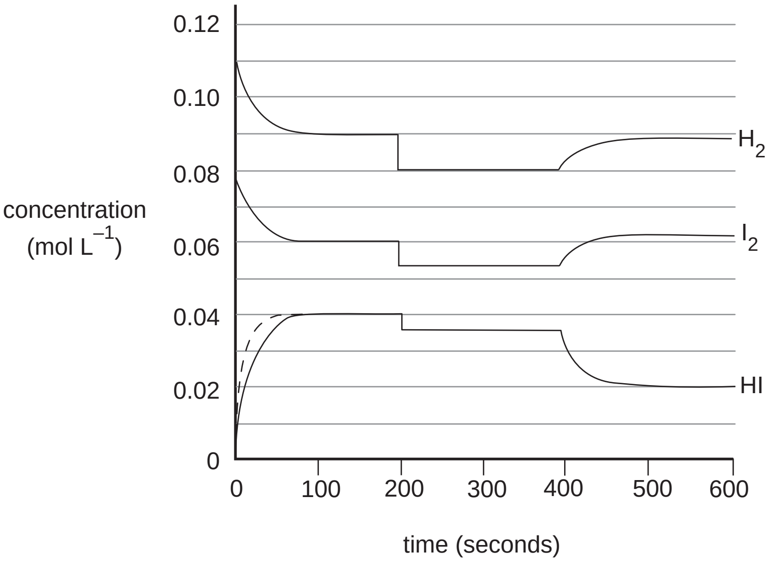
The concentration of H_2 decreased from 0.090 M to 0.080 M, so the volume was increased by a factor of $\frac{9}{8}$. 1 mark

d. **i.** lower 1 mark

ii. The concentrations of the reactants increase and the concentration of the product decreases. 1 mark

In the concentration fraction, the numerator is smaller and the denominator is larger, resulting in a smaller value of K. 1 mark

e.



Drawing on graph should show equilibrium concentration of 0.040 M being reached earlier.

1 mark