Trial Exam

2013 Unit 3-4 VCE

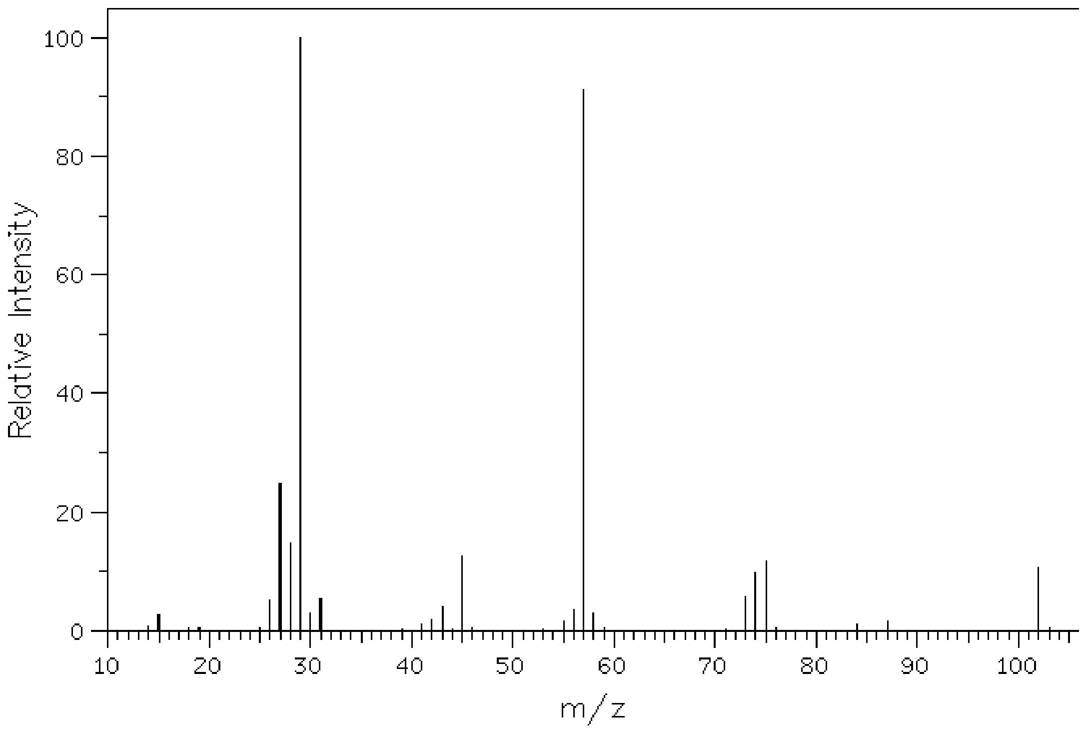
Chemistry Solutions

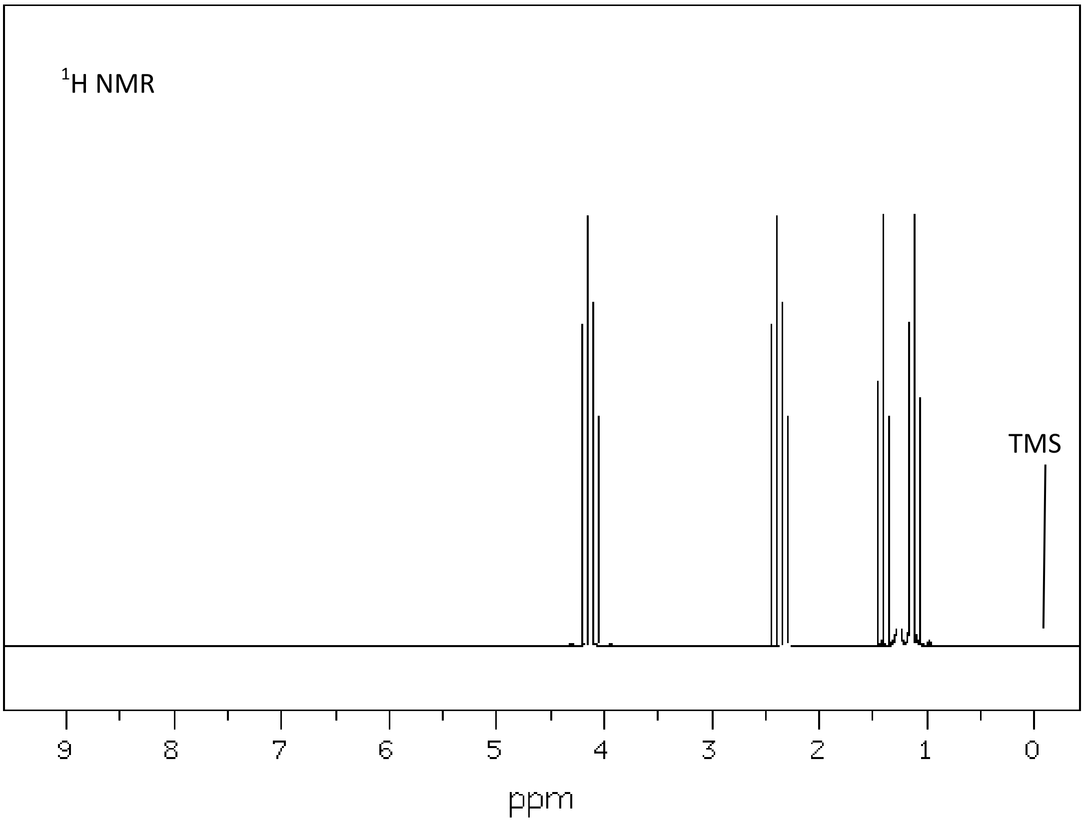
1. A [✓ B] C D
2. A [✓ B] C D
3. A B [✓ C] D
4. A B C [✓ D]
5. A B C [✓ D]
6. [✓ A] B C D
7. A B [✓ C] D
8. A [✓ B] C D
9. A B [✓ C] D
10. [✓ A] B C D
11. A B C [✓ D]
12. [✓ A] B C D
13. A B C [✓ D]
14. A B [✓ C] D
15. A B [✓ C] D
16. A B C [✓ D]
17. A B [✓ C] D
18. A B C [✓ D]
19. A B C [✓ D]
20. [✓ 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

Circle the correct response to each question on the answer sheet.

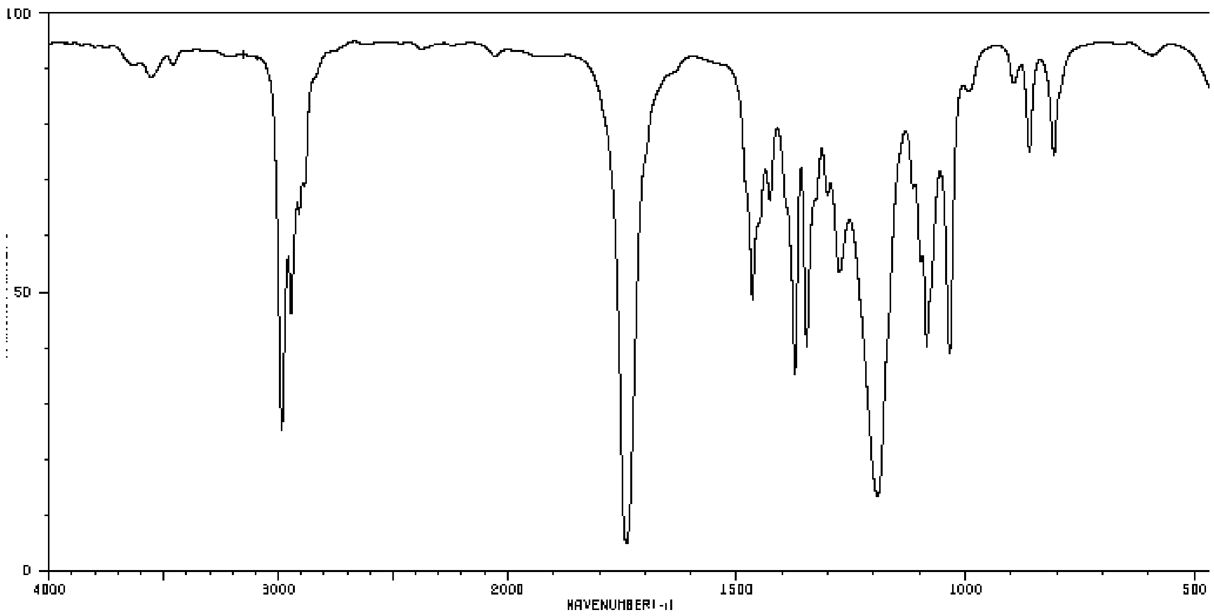
1. 1. An organic compound is analysed and found to contain the following percentage composition by mass.58.8% C, 9.8% H, 31.4% O.

The relevant spectra are shown below.





IR spectrum



a) Calculate the empirical formula of the compound.

58.8% C, 9.8 % H, 31.4%O.

convert to mass	58.8 g C,	9.8 g H,	31.4 g O.
convert to mole	$\frac{58.8\text{ g C,}}{12.0}$	$\frac{9.8\text{ g H,}}{1.0}$	$\frac{31.4\text{ g O.}}{16.0}$
=>	4.9	9.8	2
Rounding up	5	10	2

=> $C_5H_{10}O_2$ Empirical formula

b) What is the molecular formula of the compound?

$C_5H_{10}O_2$ Empirical formula

$$\frac{\text{molecular mass}}{\text{empirical mass}} = \frac{102}{102} = 1$$

$C_5H_{10}O_2$ Molecular formula

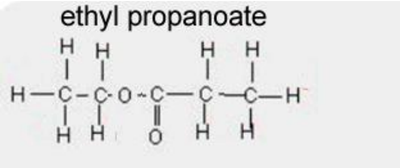
2 marks

c) What information can be deduced from the IR spectrum at 1250 cm^{-} and at 1750 cm^{-} ?

C-O and a C=O bond

1 mark

d) Draw the structural formula and name the compound in b) above.

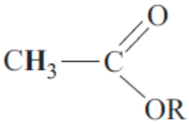


3 marks

What is the significance of a singlet at 2.0 ppm on ^{1}H NMR

The singlet at 2.0 ppm represents a CH_3 group next to a COO as shown below

1 mark



e) Give the name of the compound

Ethyl propanoate

1 mark

f) What are the names of two possible raw materials for the production of the compound in e) above?

Ethanol and propanoic acid

2 marks

g) What type of reaction forms this compound?

Condensation

1 mark

h) What is the relevance of the peak at 0 on the ^{1}H NMR spectrum labelled TMS

Trimethylsilane gives one strong peak in ^{1}H NMR as all the hydrogen atoms are identical. All other peaks form to the left of the TMS signal the distance from which is known as the coupling constant. *1 mark*

2. Given the following two molecular compounds
$(CH_3)_2CHCOOCH(CH_3)_2$ and $CH_3CH_2COOCH(CH_3)_2$
Outline the similarities and differences between the IR, ^1H NMR and ^{13}C NMR spectra of each molecule by completing the table below.

The table for ethanol is filled in for you.

Compound	IR spectrum	^1H NMR	^{13}C NMR
$CH_3CH_2COOCH(CH_3)_2$	Strong absorption at: 2850-3300 (due to C-H) 1000-1300 (due to C-O) 1670-1750 (due to C=O)	Four sets of peaks. A doublet representing the $(CH_3)_2$ A septet representing the CH A triplet representing the CH_3 A quartet representing the CH_2	Five peaks
$(CH_3)_2CHCOOCH(CH_3)_2$	Strong absorption at: 2850-3300 (due to C-H) 1000-1300 (due to C-O) 1670-1750 (due to C=O)	Two sets of peaks. A doublet representing the CH_3 A septet representing the H	Three peaks
Ethanol	Strong absorption at: 2850-3300 (due to C-H) 3200-3550 (due to O-H)	Three sets of peaks. A singlet representing the OH A quartet representing the CH_2 A triplet representing the CH_3	Two peaks

6 marks

3. The percentage of iron (Fe^{3+}) in steel wool is determined by reacting a known amount of steel wool with excess sulphuric acid producing soluble iron(III)sulphate. A 1.20g piece of steel wool is dissolved in 30.0 mL of 1.00M sulphuric acid, H_2SO_4. The excess sulphuric acid is determined by titration with a 0.050M NaOH solution. 27.0 mL of sodium hydroxide is required to neutralise the acid.

a) Write a balanced chemical equation for the reaction between sodium hydroxide and sulphuric acid.
$2Fe(s) + 3H_2SO_4(aq) \Rightarrow Fe_2(SO_4)_3\,(aq) + 3H_2(g)$

2 marks

b) Calculate the amount, in mol, of sulphuric acid that reacted with the sample of steel wool.
Amount of sulphuric acid added
$\Rightarrow n_{sulphuric\ acid} = C \times V = 1.00 \times 0.030 = 0.030$ mol
Amount of sulphuric acid that reacted with the NaOH according to the equation below
$H_2SO_4(aq) + 2NaOH(aq) \Rightarrow 2H_2O(l) + Na_2SO_4(aq)$
$\Rightarrow n_{NaOH} = C \times V = 0.05 \times 0.027 = 0.00135$
$\Rightarrow n_{sulphuric\ acid} = 0.00135/2 = 6.75 \times 10^{-4}$
$\Rightarrow$ *mole of sulphuric acid reacting* $= 0.030 - 0.000675 = 0.0293$

2 marks

d) Determine the percentage, by mass, of iron in the steel wool.

$2Fe(s) + 3H_2SO_4(aq) \Rightarrow Fe_2(SO_4)_3(aq) + 3H_2(g)$

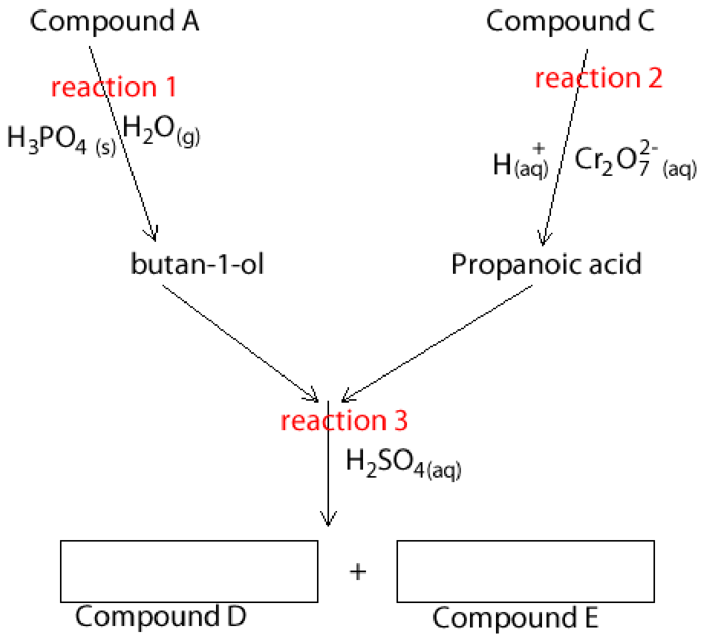
Mole of Fe^{3+} in the steel wool is (2/3) X 0.0293 = 0.0195

Mass of Fe = 0.0195 X 55.8 = 1.09 g

Percentage by mass = (1.09/1.20) X 100 = 90.8%

2 marks

4. Below is the reaction pathway of two compounds A and C



a) Give the systematic name for compound A

1 mark

But-1-ene

b) What type of reaction is

i) reaction 1 ____________*addition*________________________

ii) reaction 2 ____________*oxidation*_______________________

iii) reaction 3 _____________*esterification or condensation*____

3 marks

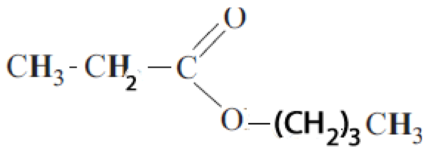
c) Identify compounds

i) D _________________*butyl propanoate*_________

ii) E ___________________*water*_________________

2 marks

d) Draw the structure of the heavier compound that results from reaction 3, showing all bonds.



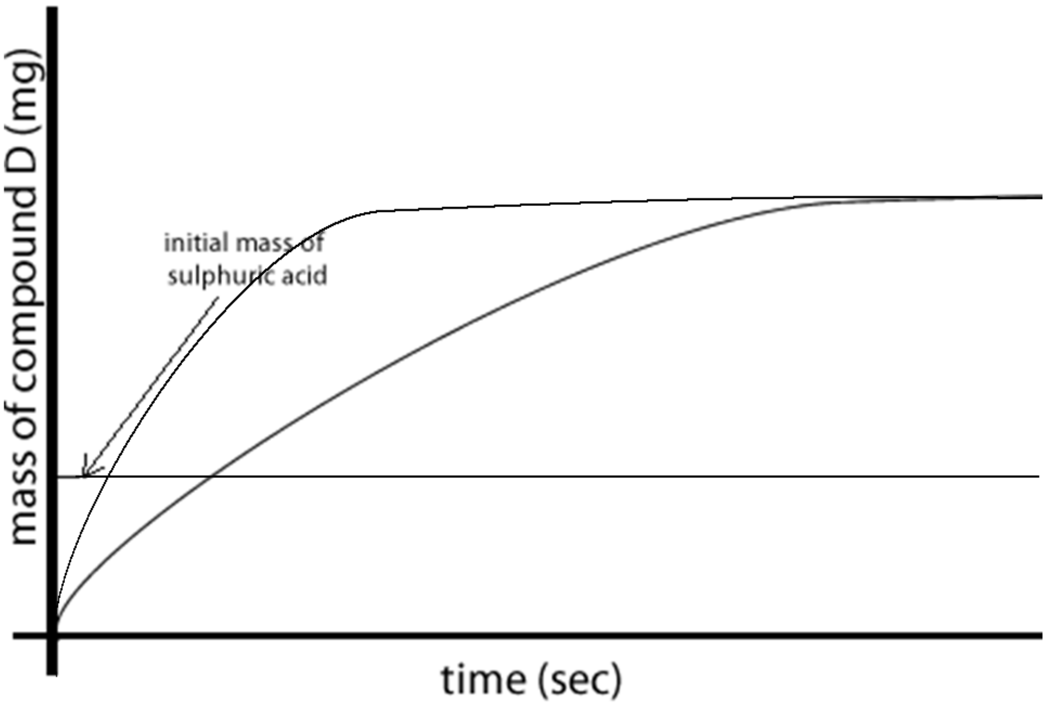
1 mark

e) The IR spectrum of the compound in question d) above contains 3 peaks of high absorption. Give the range in wave number (cm^-) where each peak is likely to be found and the bond that it represents.

Bond	Absorption range (cm^-)

3 marks

f) Below is a graph showing the mass of compound D formed over time in the absence of H_2SO_4. On the axes below draw the expected mass vs time graph **with** the H_2SO_4 present, assuming no change in the conditions under which the current graph was drawn. Give an explanation



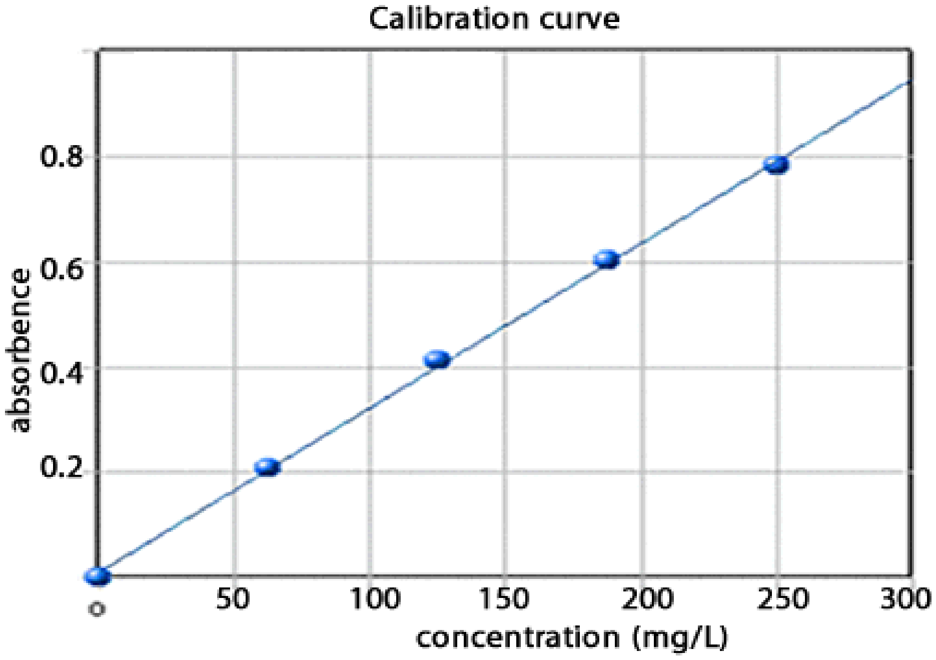
H_2SO_4 acts as a catalyst. It will speed up the rate of the reaction without been consumed.

2 marks

g) On the same graph draw how the mass of H_2SO_4 changes over the course of the reaction.

1 mark

5. A sample of shark meat was analysed for lead content. 5.12 grams of meat was crushed and dissolved completely in 100.00 mL of a concentrated NaOH solution. A 50.0 mL sample of the 100.00 mL fish solution was placed in a 500 mL volumetric flask and made up to the mark with distilled water. A 40.0 mL sample was taken from the volumetric flask and diluted to 100.0 mL with distilled water. A 20.00 mL sample of this diluted solution was then taken and analysed using atomic absorption spectroscopy and an absorbance reading of 0.48 was recorded.



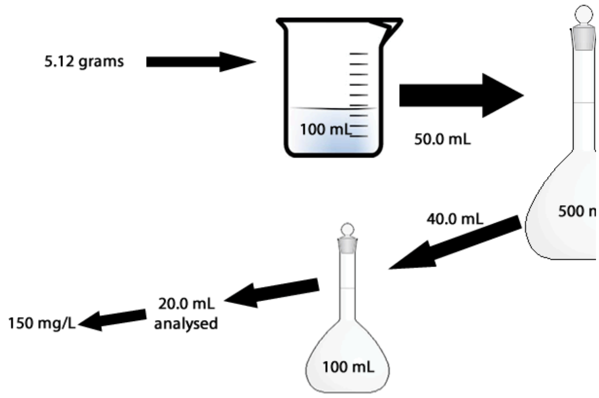
a) What is the concentration of lead of the 20.00 mL solution tested?
150 mg/L or 150 ppm

1 mark

b) What is the concentration of lead in the original sample of fish *meat* in ppm?

Amount in of lead in 20.0 mL sample analysed is
150 mg/L X 0.0200 L= 3.00mg
Amount of lead in the 100 mL volumetric flask
3.00 mg X 5 = 15 mg
Amount of lead in the 500 mL volumetric flask
15mg X 500/40 = 187.5 mg
Amount of lead in the 100 mL beaker
187.5 X 2 = 375 mg

The % by mass of lead in the sample is therefore
(375 mg/5120 mg) X 100 = 7.32 %



3 marks

c) In AAS, light is shone through the solution. Discuss which subatomic particles are involved and how they interact with the light.
Electrons of the atoms in the atomiser absorb light energy of specific wavelength and become promoted to higher orbitals (excited state) for a short period of time. The amount of energy absorbed is directly proportional to the amount of substance being investigated.

2 marks

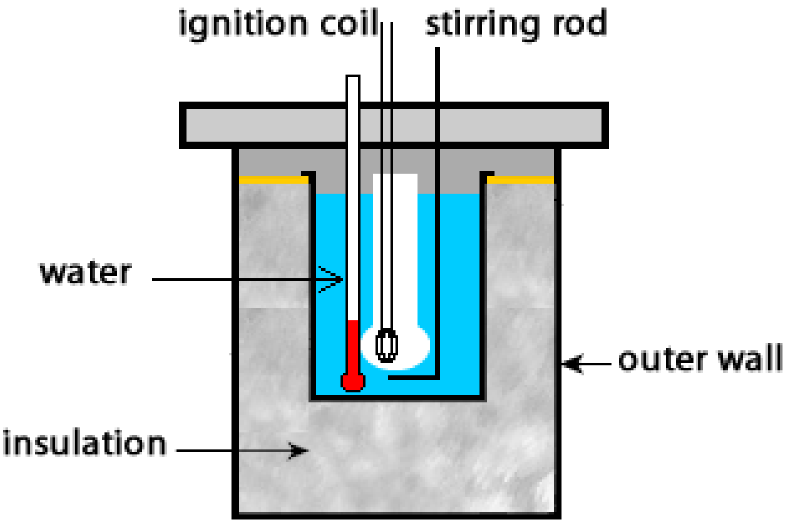
d) Explain how this light is generated and why it is important to use a precise wavelength of light.
A hollow cathode lamp made from metal which is to be determined. When excited the metal atoms emit light of specific wavelength. It is this light that will be absorbed solely by the metal atom in the solution under investigation.

2 marks

6. A bomb calorimeter, shown below, is used to determine, ***experimentally***, the ΔH of the reaction below. 11.6 grams of butane are burnt in excess oxygen to raise the temperature of the water by 2.18 ^oC

$$2C_4H_{10}(l) + 13O_2(g) \Rightarrow 8CO_2(g) + 10H_2O(g) \quad \Delta H = ?$$

The calorimeter was first calibrated by burning 6.840 g of liquid pentane in excess oxygen. The temperature of the water in the calorimeter increases from 25.0 to 26.5.



a) Calculate the calibration factor of the calorimeter?

Step 1 Calculate the amount in mol of pentane
=> 6.84 / 72 = 0.095
Step 2 calculate the amount of energy released by 0.095 mol of pentane
=> 3509 (from data book) X 0.095 = 333.36 kj
Step 3 calculate the calibration factor 333.36/1.5 = 222.24 kJ/ ^oC

2 marks

b) Why must a calorimeter be calibrated before use?

Each calorimeter is different and looses heat to the environment at different rates. So we must calculate the relationship between energy and degree rise for each one.

1 mark

c) Calculate the enthalpy change of the reaction below
$2C_4H_{10}(l) + 13O_2(g) \Rightarrow 8CO_2(g) + 10H_2O(g)$

Step1 calculate the mol of butane
=> 11.6 / 58 = 0.20
Step 2 calculate the amount of energy released by 0.20 mol of butane.
=> 222.24 X 2.18 = 484.48
Step 3 Calculate the molar heat of combustion of butane
=> 484.48 / 0.20 = 2422.4 kJ/mol
So for 2 mol, as the equation states, we would have ΔH = 4844.8kJ/mol

2 marks

d) How do you account for the molar heat of butane being lower than the value in the data sheet?
Heat escaping from the calorimeter

1 mark

e) 1) $C(s) + O_2(g) \rightarrow CO_2(g)$; ΔH = -393.5 kJ/mol

2) $S(s) + O_2(g) \rightarrow SO_2(g)$; ΔH = -296.8 kJ/mol

3) $C(s) + 2\ S(s) \rightarrow CS_2(l)$; ΔH = 87.9 kJ/mol

Given the thermochemical equations above calculate the value of the ΔH for the reaction

$CS_2(l) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ SO_2(g)$ ΔH =
Step 1 Revert equation 3
=> $CS_2(l) \rightarrow C(s) + 2\ S(s)$ *ΔH = - 87.9 kJ/mol ----- 4)*
Step 2 Add equations 1) and 4)
=> $CS_2(l) + O_2(g) \rightarrow CO_2(s) + 2\ S(s)$ *ΔH = - 481.4 kJ/mol ---- 5)*
Step 3 Add equations 2) and 5)
=> $CS_2(l) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ SO_2(g)$ *ΔH = 778.2 kJ/mol*

2 marks

f) A camper has 0.360 grams of propane left in his bottle and needs to boil 50.0 mL of water for tea.

i) Write a balanced equation for the combustion of propane

$C_3H_8(g) + 5O_2(g) \Rightarrow 3CO_2(g) + 4H_2O(l)$

1 mark

ii) Assuming that the cooking utensil used is 60% efficient in transferring heat energy into the water, calculate the maximum temperature that the 50.0 mL of water will reach if its initial temperature is 18 °C.

Step 1 Calculate the mol of propane

=> 0.360 / 44 = 0.00818

Step 2 Calculate the amount of energy released from 0.00818 mol of propane

=> 0.00818 mol X 2217kJ/mol = 18.135kJ

Step 3 Calculate the amount of energy absorbed by the water

=> 18.135 kJ X 60% = 10.881 kJ

Step 4 Calculate the degree rise of 50 mL of water (density of water 1g/cm^3)

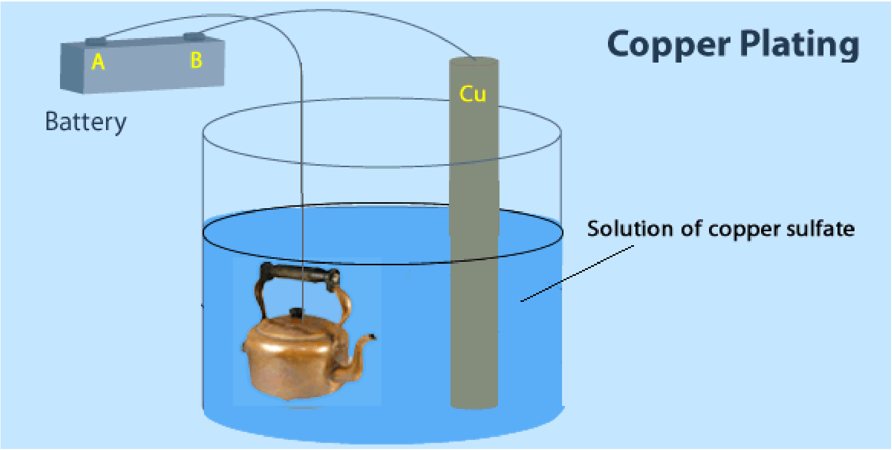
=> to raise 50 mL by 1 °C we require 50 X 4.18 J = 0.209 kJ

=> 10.881/ 0.209 = 52.06 °C

Final temperature 18.0 + 52.1 = 60.1 °C

3 marks

7. A iron kettle is to be copper plated using an electrolytic cell, as shown below. A total surface area of 55.8 cm^2 is to be copper plated to a depth of 2.00 mm.
Density of copper metal is 8.933 g/cm^3.



a) Write the equation for the reaction occurring at the:

i) anode ___________*$Cu(s) \Rightarrow 2e + Cu^{2+}(aq)$* ________________

ii) cathode ____________*$2e + Cu^{2+}(aq) \Rightarrow Cu(s)$* ______________

2 marks

b) What is the polarity of terminal:

i) A __-__

ii) B _+___

1 mark

c) How long, in hours, should a current of 1.80 A flow. Express the answer to the right number of significant figures?

Step 1 calculate the mass of copper to be plated on to the tea pot.
Mass = density X volume
=> mass$_{copper}$ = 8.933 X (55.8 X 0.2) = 99.7g
Step 2 calculate the mol of copper
=> n$_{Cu}$ = 99.7 / 5 8.9 = 1.69 mol
Step 3 calculate the mol of electrons needed
For every mole of copper to be deposited we need 2 mol of electrons
=> n$_{electrons}$ = 1.69 X 2 = 3.38
Step 4 calculate the charge of 3.38 mol of electrons
=> 3.38 X 96500Q = 326170 Q
Step 5 calculate the time needed
=> Q = It
=> Q/I = t
=> 326170/1.80 = 181205 sec
=> 50.3 hours

3 marks

d) i) What will happen to the concentration of Cu^{2+} ions in the solution?

Remain unchanged

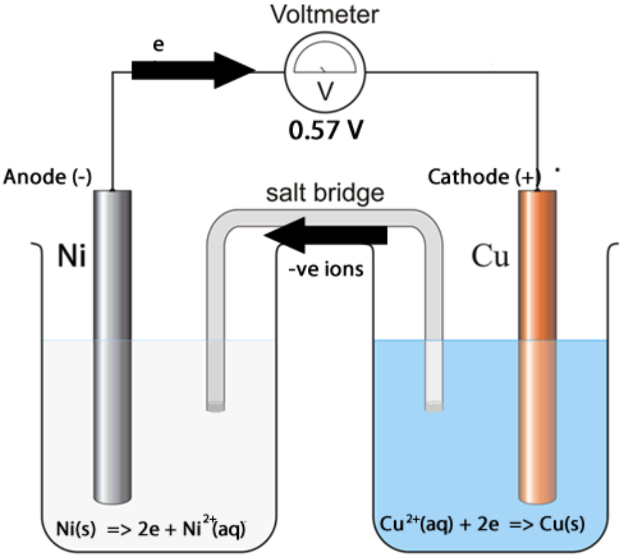
1 mark

ii) Give an explanation

The mol of copper that is reduced at the cathode (pot) is equal to mol of copper that is oxidised at the anode (copper electrode)

1 mark

8. Consider the galvanic cell shown below.



a) On the diagram above indicate the following
   i) direction of electron flow
   ii) direction of negative ion movement
   iii) the anode
   iv) the cathode
   v) polarity of each electrode
   vi) the EMF of the cell

3 marks

b) Give the half-cell equation occurring at the
   i) anode

   ii) cathode

2 marks

c) The copper half-cell contains 100.0 mL of a 0.100 M $CuSO_4$ solution. A small current of 2.02 X 10^{-3} A is produced and allowed to run for 48 hours. What is the concentration of the $CuSO_4$ solution, in mol per litre, after the 48 hour discharge?

Step1Calculate the mole of electrons produced?
=> Q = It
=> Q = 0.00202 X 48 X 60 X 60 = 349.1
=> 349.1 / 96500 = 0.00362
Step 2 calculate the mol of copper deposited
=> Cu^{2+}(aq) + 2e => Cu(s)
=> 0.00362 / 2 = 0.00181 mol
Step3 calculate the mol of copper remaining in the 100 mL solution
=> mol of copper remaining = mol initial – mol used
=> mol of copper remaining = 0.010 – 0.00181 = 0.00819
Step 4 calculate the concentration
=> C = n/V => 0.00819 / 0.1 = 0.082M

2 marks

9. At a given temperature a 3.44 g sample of phosphorus pentachloride (208.5 gmol^{-}) is placed in a 2.34 litre vessel where it decomposes according to the equation below.

$$PCl_5\ (g) <\!\!-\!\!-\!\!> PCl_3\ (g) + Cl_2\ (g)$$

The decomposition reaction is allowed to come to equilibrium. It was found that the equilibrium mixture contained 1.03 grams of chlorine gas.

a) What percentage of the original PCl_5 decomposed?

Step 1 find the mole of PCl_5
=> $n = 3.44 / 208.5 = 0.0165$
step 2 find the mole of Cl_2
=> $n = 2.34 / 71.0 = 0.0145$
Step 3 find the mol PCl_5 *that reacted.*
=> $n = 0.0145$
Step 3 find the percentage PCl_5 *that reacted*
=> $(0.0145/0.0165) \times 100 = 87.9\%$

2 marks

b) Calculate the equilibrium constant for this reaction at the temperature the reaction took place.

$$\frac{[Cl_2]\,[PCl_3]}{[PCl_5]}$$

$$= \frac{[0.00620\ ]^2}{[0.000854]}$$

$$= \frac{[0.00620\ ]^2}{[0.000854]}$$

$$= 0.045$$

2 marks

c) Consider the reactions given below which are at equilibrium. Predict the outcomes after the stated change by filling the table below. Circle the correct response.

Reaction at equilibrium	Change	Equilibrium constant	Equilibrium position
$2H_2(g) + O_2(g) \rightleftharpoons 2\,H_2O(g)\ \Delta H_m = -\ \text{kJ mol}^{-1}$	Volume of the reaction vessel is halved	Increase Decrease [✓ Unchanged]	[✓ Shifts to the left] Shifts to the right No change
$CH_4(g) + 2O_2(g) \rightleftharpoons CO_2(g) + 2H_2O(g)\ \Delta H_m = -\ \text{kJ mol}^{-1}$	Temperature is increased	Increase [✓ Decrease] Unchanged	[✓ Shifts to the left] Shifts to the right No change
$2A(aq) + B(aq) \rightleftharpoons C(aq) + 2D(aq)\ \Delta H_m = +\ \text{kJ mol}^{-1}$	Volume is doubled by the addition of distilled water	Increase Decrease [✓ Unchanged]	Shifts to the left Shifts to the right [✓ No change]

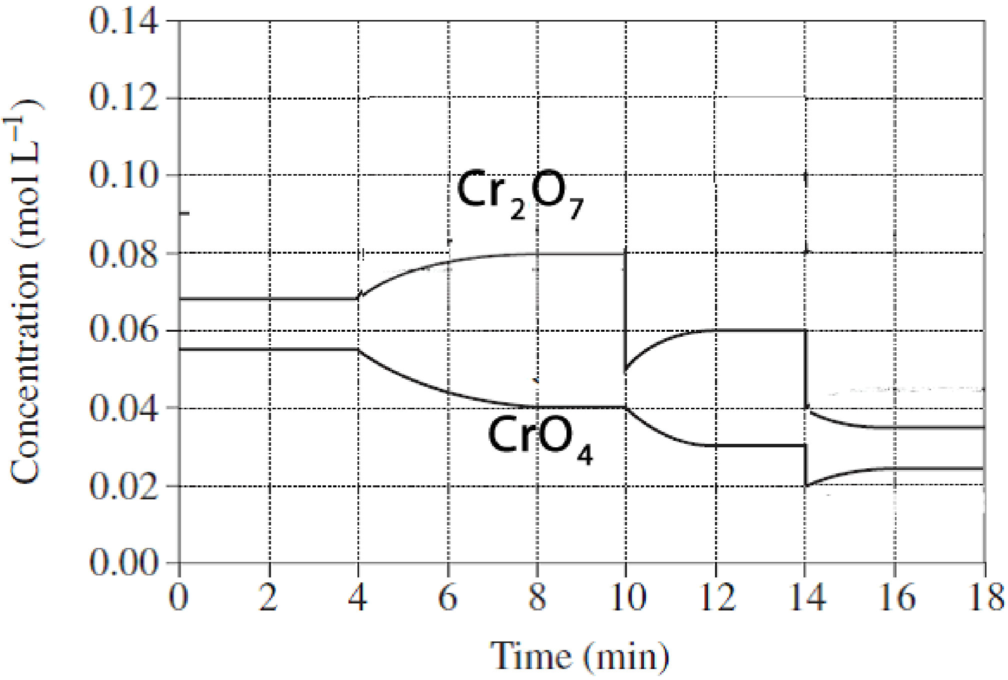
$2A(aq) + 2B(aq) \rightleftharpoons C(aq) + 2D(aq)$ ΔH_m = + kJ mol^{-1}	Addition of Cl$^-$ ions without a change in volume	Increase Decrease [✓ Unchanged]	Increase Decrease [✓ Unchanged]

3 marks

d) Consider the reaction shown below. An acidified solution of chromate ions (CrO_4^{2-}) is allowed to come to equilibrium according to the equation shown below.

$$2CrO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \rightleftharpoons Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)} \quad \Delta H = \text{positive}$$

Chromate ions are yellow while dichromate ions appear red in solution.
The graph below shows the concentration of each species over time.



i. What two events could have happened at 4 minutes to shift the equilibrium as indicated in the graph?
Temperature increase
pH decreased by the addition of an acid

2 marks

ii. Assuming the temperature of the solution remained unchanged what possibly happened at 14 minutes?
Water was added to dilute the equilibrium mixture

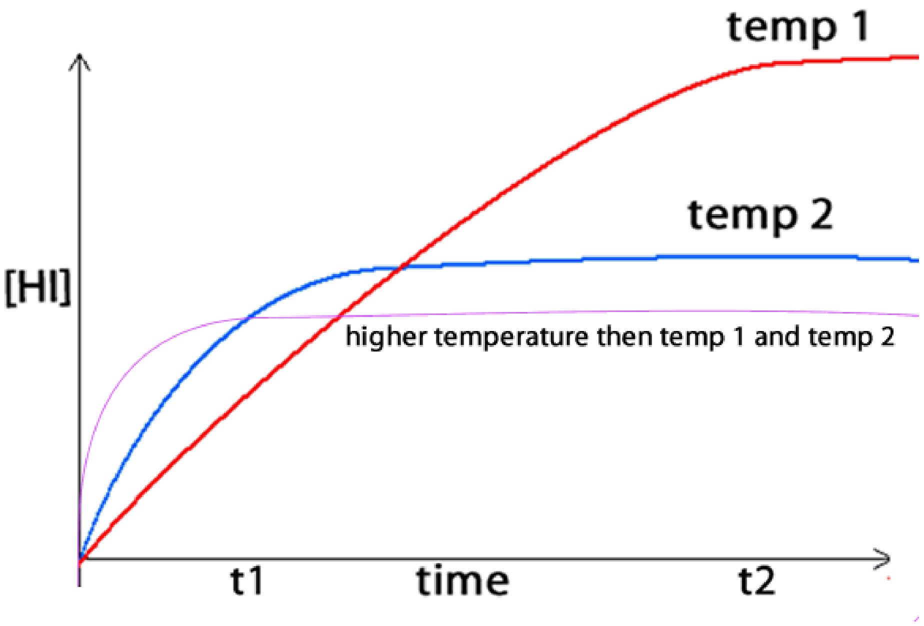
1 mark

iii. What event resulted in the equilibrium shift shown at the 10 minute mark?
Cr_2O_7 *is removed probably by the addition of a precipitating agent.*

1 mark

iv. At the 16 minute mark a catalyst was added. Describe how the equilibrium responds.
No change.

1 mark



e) Into a 2 litre sealed vessel was placed 2.0 mol of H_2 gas and 2.0 mol of I_2 gas and allowed to reach equilibrium. The graph of HI concentration is shown above at two different temperatures.

i. Which temperature is the greatest? Give an explanation
Temp 2 is the greatest as the rate is faster than in temp1.

1 mark

ii. Decide whether the reaction is exothermic or endothermic and give a reason.
Endothermic because at the greater temperature we have less yield.

1 mark

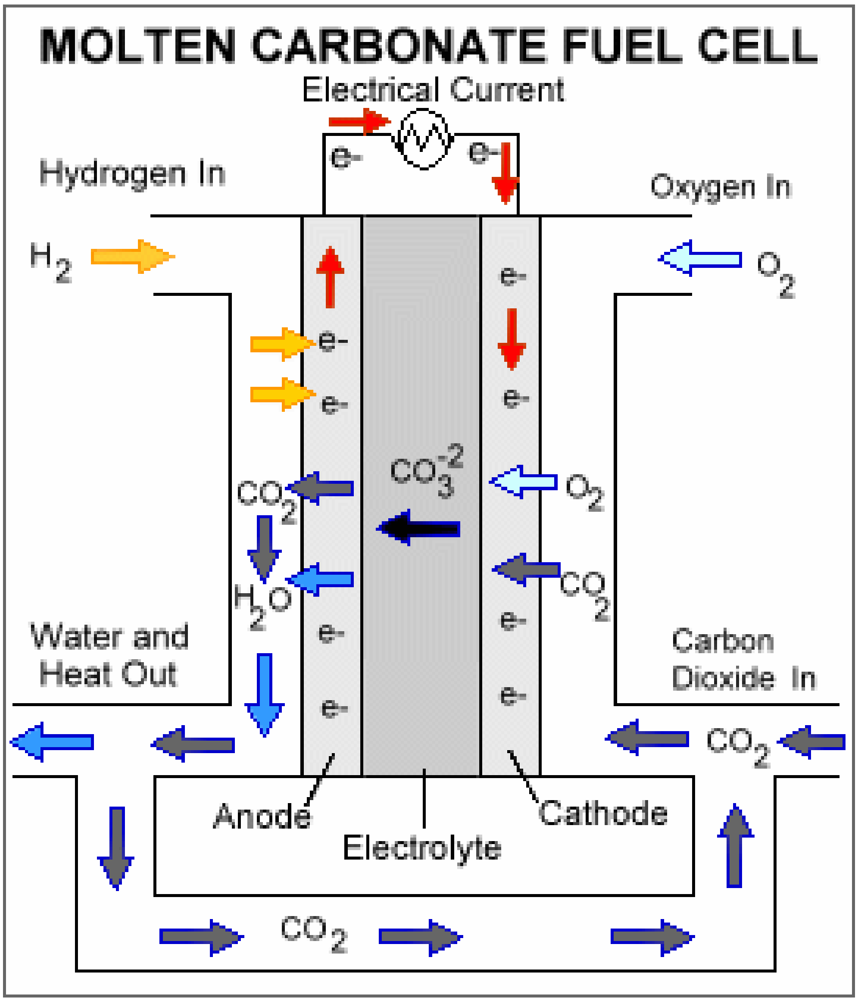
iii. "At t2 the forward reaction has stopped."
Is this comment true or false? *False*
Give a clear explanation as to why.
Although the graph shows no change in HI both reverse and forward reactions are taking place at exactly the same rate. So product formed= product broken down.

1 mark

iv. Draw the graph of [HI] at a temperature higher than both temp 1 and temp 2.

1 mark

10. A molten carbonate fuel is just one example of an alkali fuel cells. This fuel cell operates at temperatures above 600 °C. A shown below it uses carbon dioxide, hydrogen and oxygen as inputs.



a) Give the half equation that occurs at the anode
$H_2 \Rightarrow 2H^+ + 2e$

1 mark

b) Give the half equation that occurs at the cathode
$O_2 + 4e \Rightarrow 2O^{-2}$

1 mark

c) Molten carbonate fuel cells do not produce green-house gases and are therefore more environmentally friendly than fossil fuels, however, carbon dioxide is produced at the anode. Explain.
As shown in the diagram, carbon dioxide is recycled

1 mark

d) Consider the galvanic cell, shown in question 8. Name three differences between the electrodes of that galvanic cell and this fuel cell.
Electrodes in a fuel cell are not used up but they are in the galvanic cell shown in Q8.
In a fuel cell electrodes act as catalysts in the galvanic cell they do not.

In a fuel cell the electrodes are porous to allow the passage of ions in the galvanic cell they are not.
2 marks

e) Apart from the electrodes, when considering the operation of a galvanic cell and a fuel cell what are two differences between them?
In a fuel cell products are constantly removed while in a galvanic cell they build up. Reactants constantly supplied in a fuel cell whereas in a galvanic cell there is a finite amount of reactants.

2 marks

f) It is suggested that this cell can be coupled onto conventional fossil fuel power generators to make them more environmentally friendly. Explain how this would make them environmentally friendly?
It uses carbon dioxide as an input so it can capture and use the carbon dioxide from conventional power generators.

1 mark

g) Ethanol is said to be an alternative fuel source that is carbon neutral. What is meant by the term carbon neutral?
It does not add to the atmospheric carbon sink. The carbon in ethanol is taken out of the atmosphere through photosynthesis and put back during combustion.

1 mark

h) Give the balanced chemical equations, states not required, of the process by which CO_2 is taken out of the atmosphere and stored in the biomass of plants. Explain why this is a redox reaction
$6CO_2(g) + 6H_2O(l) \Rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
Carbon in CO_2 *goes from a state of +4 to 0 in glucose*
Oxygen goes from a state of -2 to 0

2 marks

i) Give the balanced chemical equation for reaction that converts glucose to ethanol during fermentation and explain why it is an redox reaction.

$C_6H_{12}O_6(aq) \Rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$
C in glucose has an oxidation state of 0
C in ethanol has an oxidation state of -2
C in CO_2 *has an oxidation state of +4*

2 marks

j) Cars capable of running on hydrogen fuel cells are been developed.
i. Discuss two advantages of hydrogen fuel over fossil fuel.
Renewable through the electrolysis of water.
Does not produce carbon dioxide as a product.

2 marks

ii. Discuss two disadvantages of using hydrogen as a fuel source.
High pressure, low temperature containers makes it very expensive to maintain. The production of hydrogen is not without carbon pollution.

2 marks

11. Bicarbonate buffering is an important chemical system in the human body. Like all buffering systems, it tends to maintain a relatively constant blood pH. This system is represented by the equation below. Carbon dioxide (CO_2) reacts with water to form carbonic acid (H_2CO_3). Carbonic acid then dissociates to form hydrogen carbonate (HCO_3^-) ions.

$$CO_2(aq) + H_2O(l) \rightleftarrows H_2CO_3(aq) \rightleftarrows HCO_3^-(aq) + H^+(aq)$$

a) A 0.667 mol of H_2CO_3 is placed in a 4.00 litre vessel filled with water and allowed to reach equilibrium at an unknown temperature. Given the acidity constant K_a of H_2CO_3 at this temperature is 4.40 X 10^{-5} fined the pH of the solution.
Step 1 Find the molarity of H_2CO_3
=> 0.667 / 4.00 = 0.167M

$$\frac{[H_3O^+]^2}{[H_2CO_3]} = 4.40 \text{ X } 10^{-5}$$

$$\Rightarrow \quad \frac{[H_3O^+]^2}{[0.167]} = 4.40 \text{ X } 10^{-5}$$

$$\Rightarrow \quad [H_3O^+]^2 = 4.40 \text{ X } 10^{-5} \text{ X } [0.167]$$

$$\Rightarrow \quad [H_3O^+] = \sqrt{4.40 \text{ X } 10^{-5} \text{ X } [0.167]} \quad = 7.35 \text{ X } 10^{-6}$$

$$= 10^{-5.13}$$

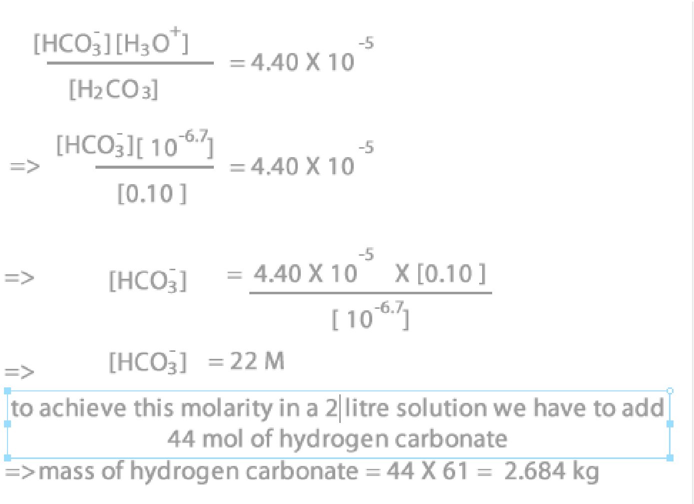
$$\Rightarrow \quad pH = 5.13$$

2 marks

b) In calculating the pH of the solution in question a) above, what assumption/s did you make and why?
Assume that the concentration of carbonic acid does not change. Being a weak acid its ionisation is very low.

1 mark

c) Suppose a solution of pH 6.7 is required at the same temperature as in a) above. To a 2.00 litre solution of 0.100 M H_2CO_3 what amount in grams of sodium hydrogen carbonate should be added?



$$\frac{[HCO_3^-][H_3O^+]}{[H_2CO_3]} = 4.40 \text{ X } 10^{-5}$$

$$\Rightarrow \frac{[HCO_3^-][10^{-6.7}]}{[0.10]} = 4.40 \text{ X } 10^{-5}$$

$$\Rightarrow [HCO_3^-] = \frac{4.40 \text{ X } 10^{-5} \text{ X } [0.10]}{[10^{-6.7}]}$$

$$\Rightarrow [HCO_3^-] = 22 \text{ M}$$

to achieve this molarity in a 2 litre solution we have to add 44 mol of hydrogen carbonate

=>mass of hydrogen carbonate = 44 X 61 = 2.684 kg

2 marks

2,680 g

d) What would happen to the amount of carbon dioxide gas that can be dissolved in a body of water if the pH of the water decreases? Explain

It would decrease

As pH decreases greater amount of H^+ ions exist driving the reaction below to the left

$$CO_2(g) \Leftrightarrow CO_2(aq) + H_2O(l) \Leftrightarrow H_2CO_3(aq) \Leftrightarrow HCO_3^-(aq) + H^+(aq)$$

1 mark

e) Discuss why amino acids, or H_2CO_3/HCO_3^- mixtures, are used as buffer solutions and not HCl.

Buffers maintain the pH of a solution

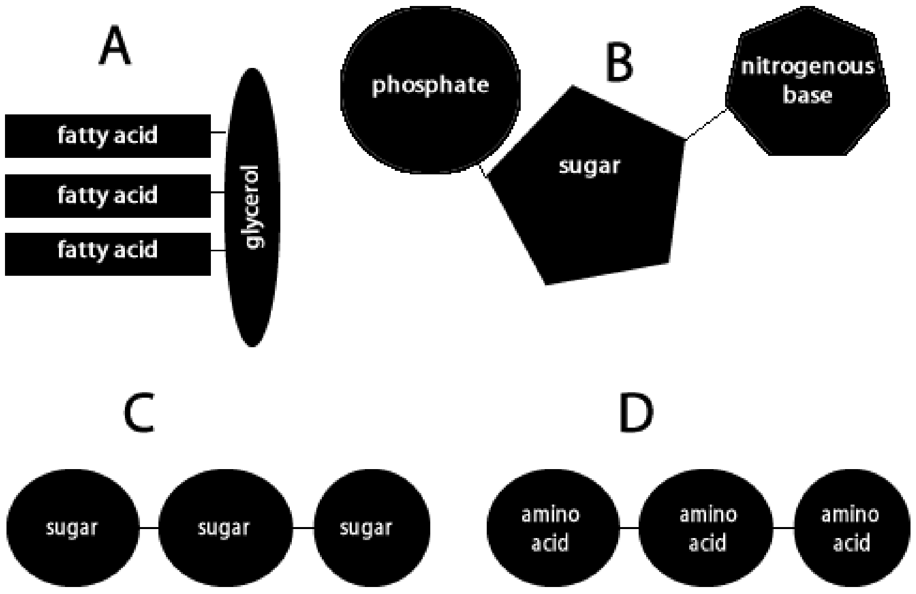
Hydrogen carbonate is a weak acid so it exists in equilibrium with is conjugate base the hydrogen carbonate ion according to the equation below.
$H_2CO_3(aq) + H_2O(l) \Leftrightarrow HCO_3^-(aq) + H_3O^+(aq)$
So if OH^- are added to the system the equilibrium shifts to the right to replace the H_3O^+ used up. If H^+ is added the equilibrium shifts to the left to absorb them.

HCl is a strong acid and so it fully ionises. In solution there exists only Cl^- and H_3O^+ ions according to the equation $HCl(aq) + H_2O_{(l)} \Rightarrow H_3O^+(aq) + Cl^-(aq)$. If, for example, OH^- is added to the system cannot respond as there is no HCl present to push the the reaction to the right and reinstate the $[H_3O^+]$.

Amino acids contain both a base and an acid group. So it can act as an acid to mop up OH^- that may have been added to the system or act as a base to mop up H^+ ions added to the system.

3 marks

12. Consider the diagram below showing the subunits of 4 bio-macromolecules.



a) i. In which molecule/s would an ester bond be found __________A____________
ii. In which molecule/s would an amide link be found __________D____________
iii. In which molecule/s would an ether link be found __________C___________
v. Which molecule/s are found in a nucleic acid ______________B___________

2 marks

b) Give the chemical formula of a molecule that is produced when the structural sub units bond to form the molecules shown above. _____H_2O_________

1 mark

c) A protein chain coils up into a unique shape as it is being synthesised. At temperatures above 50 ^{o}C the protein unfolds. Explain why and identify the type of bonds that are involved.
Hydrogen bonds, holding different parts of the protein chain close to each other, are broken at temperatures around 50 ^{o}C. These bonds are weak compared to covalent bonds and break at temperatures around 50 ^{o}C.

2 marks

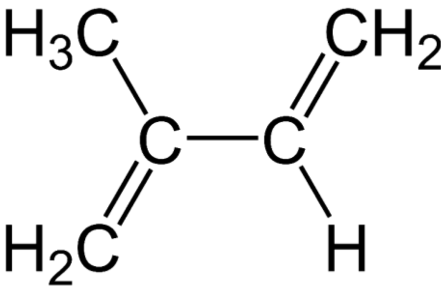
d) The protein keratin is an important component of hair and nails. A large proportion of keratin is composed of cysteine. Explain how cysteine creates such a strong, structural protein.

Cysteine forms disulphide bonds which are covalent bonds and extremely strong when compared to the weaker hydrogen bonds.

1 mark

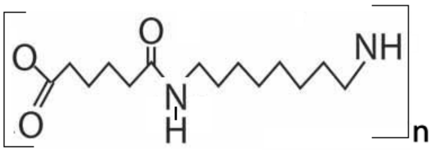
e) What is the systematic name of the molecule known as isoprene, shown on the right.

2-methyl-but-1,3-diene

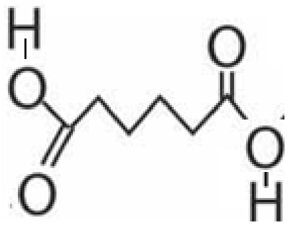


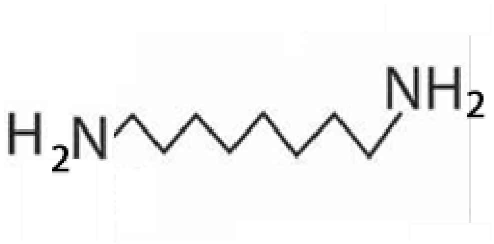
1 mark

f) The structure shown on the right represents the repeating unit of a polymer used in the manufacture of plastic pipes.



i. What are the structural formulae of the two monomers used to make this polymer.





2 marks

ii. What type of reaction can this be classified as?
Condensation

1 mark

iii. What type of bond is formed between the two monomers?
Amide

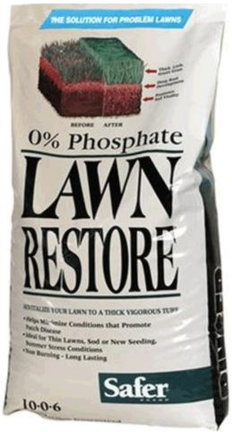
1 mark

g) Isoprene reacts with hydrogen bromide (HBr) to produce new compounds.
i. Name the possible isomers formed.
2,5-dibromo-2-methyl-pentane 1,5-dibromo-2-methyl-pentane,
2,4-dibromo-2-methyl-pentane 1,4-dibromo-2-methyl-pentane,

2 marks

ii. What type of reactionakes place between isoprene and HBr?
Addition

1 mark



13. A student conducted an investigation to show that a brand of fertiliser, that stated it had 0% phosphate, did indeed have phosphate and was contaminating the local lake. She allowed farmers to use the fertiliser on a Monday and later measured the phosphate levels of the lake on Tuesday 9 am, Wednesday 4 pm, Thursday 1 pm, Friday 6 am and Saturday 7 pm. Each day she sampled a different location of the lake. The lake is also a source of drainage water from a local residential area where Saturday is a non-working day.

On each sampling day the student took a 150.0 mL sample of lake water from which she took three 20.0 mL samples and added excess 0.01M $Ca(NO_3)_2$ solution. She then filtered, washed and dried the $Ca_3(PO_4)_2$ precipitate before weighing it. Below are her results.

Day	Tuesday	Wednesday	Thursday	Friday	Saturday
Amount of PO_4^{-3} (grams)	88 ppm	85 ppm	78 ppm	92 ppm	160 ppm

From her results the student concluded the fertiliser definitely contained phosphate which was washing into the lake.

a) Give two reasons why her experimental technique will not enable her to reach a valid conclusion.
The results have no reference point. Should have taken the concentration of phosphate in the lake before the fertiliser was used.

different parts of the lake may show varying concentrations of phosphate at different times of the day

2 marks

b) Give three ways in which the investigation could be improved and the reason for the change.

Change	Reason
Take readings at the same time every day and at the same spot on the lake.	This should account for different human activities throughout the day that may contribute to phosphate levels and also may account for different concentrations at different parts of the lake due to decomposition or
Measure the natural concentration of phosphates in the lake.	This should give a reference point from which to say if levels have changed due to the fertiliser.
Do not take a measurement on Saturday.	Possible that Human activity is contributing to phosphate levels.

3 marks

3

End of Examination