SAMPLE PAPER II IB CHEMISTRY SL

Abstract

This is a sample paper which covers all 11 of the core SL topics.
Full answers and video explanations to these questions are available at studynova.com

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Topic 1- Stoichiometric relationships.

Q1. Carbonic acid (H_2CO_3) is the weak acid which forms when $CO_2(g)$ from the atmosphere dissolves in the oceans and then reacts with the water in it. The levels of carbonic acid in the oceans are being constantly monitored as evidence of damage to coral reefs and shelly organisms continues to rise.

(a) A student in a school lab wanted to simulate ocean acidification on a small scale. They reacted hydrochloric acid with calcium carbonate chips according to the balanced equation below:

$$2HCl(aq) + CaCO_3(s) \rightarrow CO_2(g) + H_2O(l) + CaCl_2(aq)$$

[3marks]

If the student used $40cm^3$ of $2.5mol.dm^{-3}$ HCl and 5.67g of $CaCO_3$, determine which was the limiting reagent and thus how much $CO_2(g)$ that could be theoretically produced in this reaction.

(b) Once the $CO_2(g)$ was bubbled over into a beaker of water, it reacted with the water in the beaker and produced carbonic acid according to the equilibrium below:

$$CO_2(g) + H_2O(l) <-> H_2CO_3(aq)$$ [2marks]

Write the equilibrium equation for carbonic acid reacting with water and identify the conjugate acid and the conjugate base.

(c) In order to determine the actual concentration of H_2CO_3 which was produced in the beaker, the student carried out an acid-base titration. The student used 0.2mol.dm^{-3} NaOH(aq) to titrate against 20cm^3 of the acidic water and obtained the following results.

Initial reading (+/-0.05cm^3)	0.00	11.50
Final reading (+/-0.05cm^3)	11.50	21.50
Titre		

(i) Calculate the average titre to the correct number of significant figures and include the overall uncertainty of this calculation. [2 marks]

(ii) Write the balanced equation for the reaction which occurs between the NaOH and the H_2CO_3 in this titration and then determine the concentration of the H_2CO_3 which was in the sample of water. [3 marks]

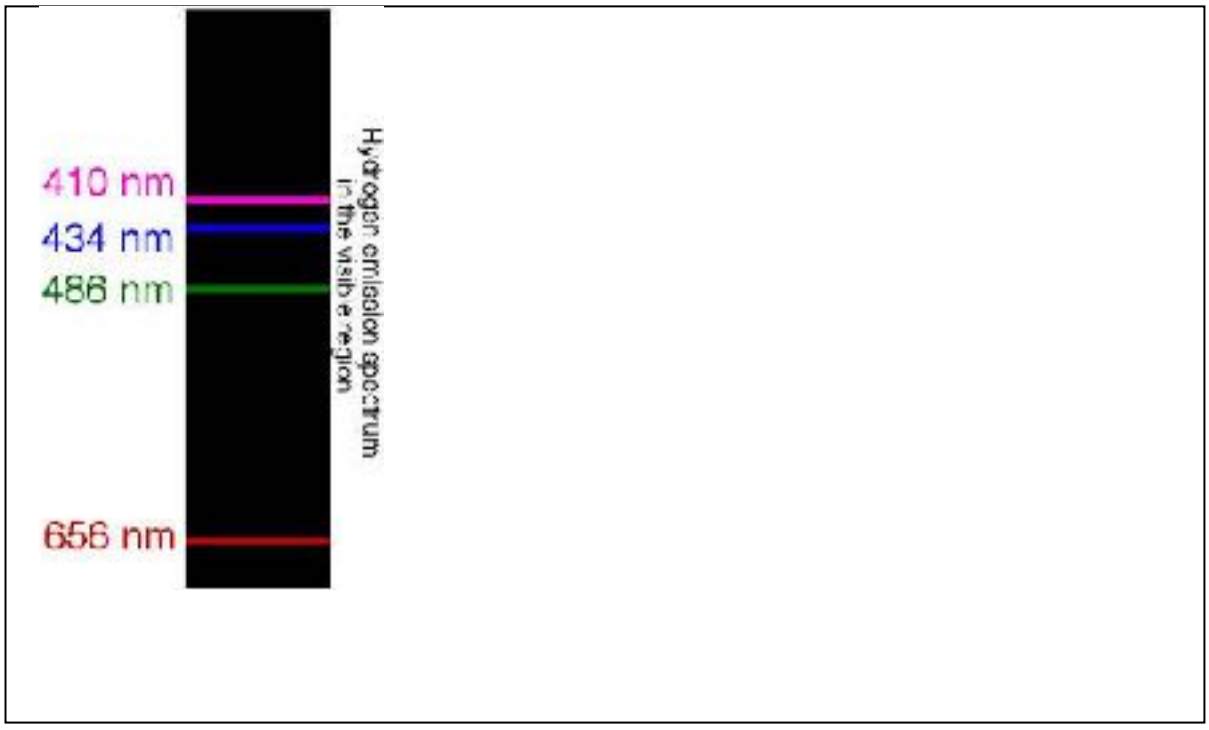
(d) Studies have shown that in cooler parts of the ocean, for example near the north pole, the pH of the oceans is lower than in warmer regions. Suggest why temperature could affect the pH of the oceans. [1mark]

Topic 2- Atomic structure

The element Helium was actually discovered in emissions from the sun before it was discovered on Earth- Hence being named after the Greek word 'Helios'.

The scientists at the time, were looking up at the emission spectra of the gaseous elements around the sun and started to notice patterns. They then turned their spectroscopes 'down' to begin to analyse the gasses already on the Earth…….

Q2. (a) The Hydrogen emission spectrum was the first to be explored. Draw a diagram to show the links between the emission spectrum of hydrogen and the Neils Bohr atomic model of a H atom.
[3marks]



(b) Draw the H-emission spectrum below and use arrows to show two emissions, one in the U.V. region and one in the visible region of the electromagnetic spectrum. [3 marks]

(c) (i) One of the lines of emission for Hydrogen appears as red light (656nm) on its emission spectrum. Calculate the energy of this wavelength of light using formulae and constants from section 1 and 2 of your I.B. data book. [3 marks]

(d) The concept of electrons occupying different types of orbitals at fixed/quantized energy levels was derived from studying the emission spectrum of hydrogen and other elements.

(i) Using the energy level diagram provided below and boxes to represent orbitals, add electrons to show the arrangement in a copper atom. [2 marks]

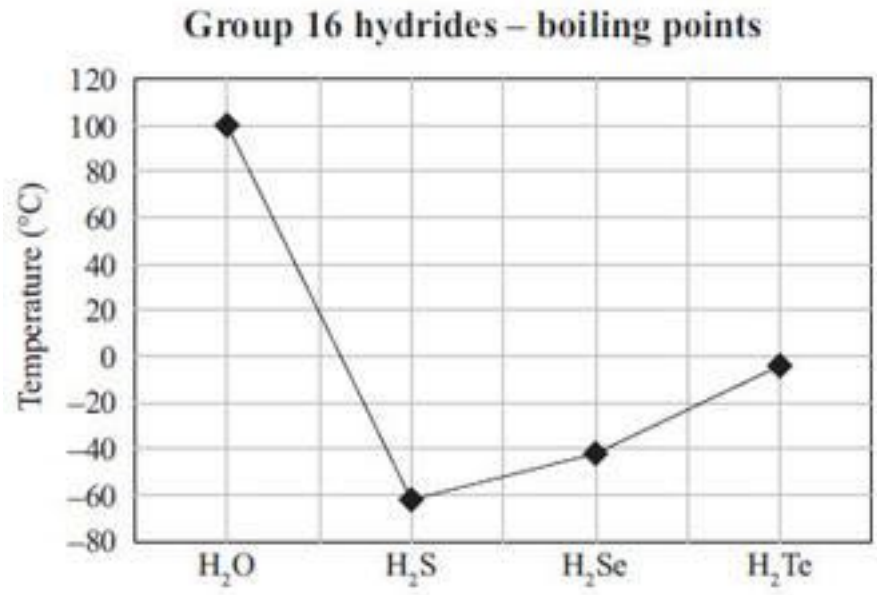
(ii) Why does the copper atom adopt the electron configuration which you have written above instead of following the normal filling order. [1 mark]

Q3. The trend in the period 3 oxides is one of interest. Deduce whether the following oxides will form acidic or alkaline aqueous solutions and write the balanced equation to support your choices.

$Na_2O(s)$, $P_4O_{10}(s)$ and $NO_2(g)$ [5marks]

Al_2O_3 (s) can be described as amphoteric. State what this means and how it differs from water which is amphiprotic (No equations are necessary) [1 mark]

Q4. (a) Explain the trend in boiling point for the group 16 hydrides shown, in terms of the intermolecular bonding present. [3 marks]



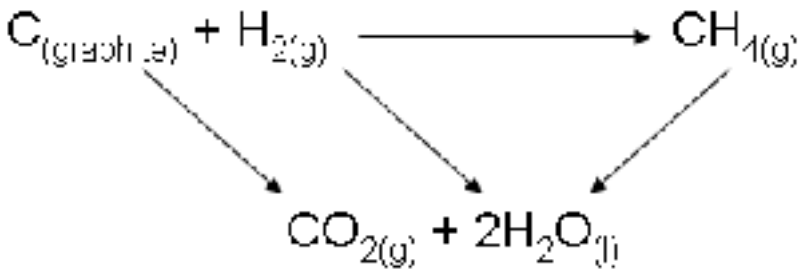
(b) Suggest why solid water (ice) is less dense than liquid water. [1 mark]

Q5 (a)
(i) Write the equation for the enthalpy of formation of methane gas under S.A.T.P [1 mark]

(ii) If the enthalpy of formation of methane is not known, it can be determined by applying Hess's law. **State**

Hess's law. [1 mark]

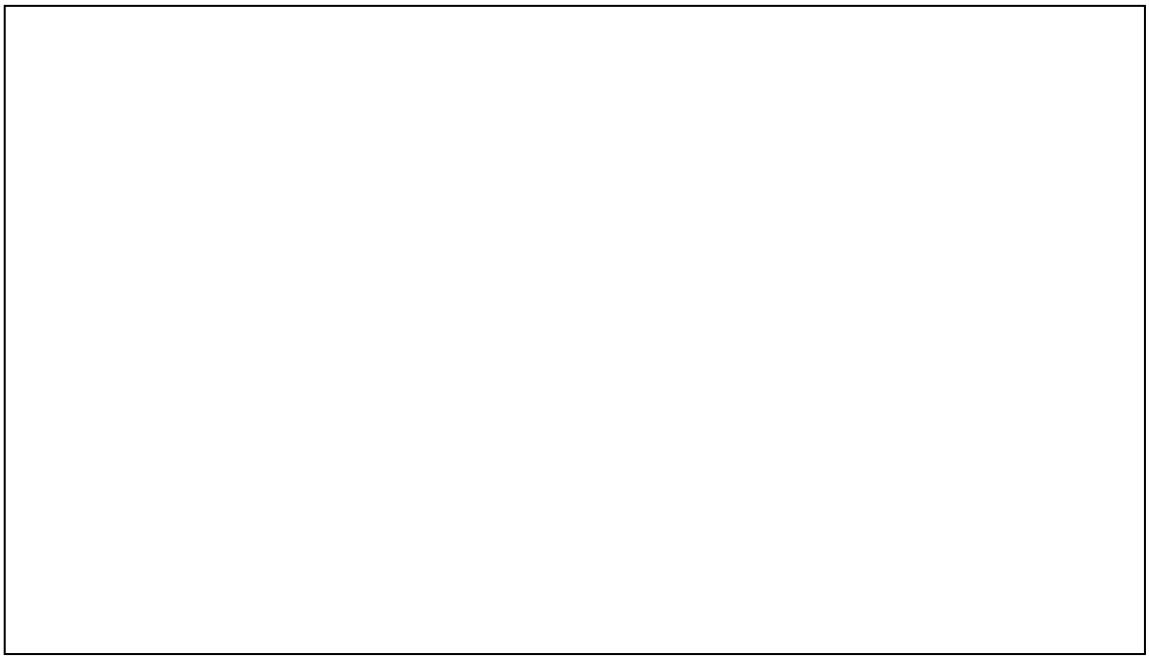
(iii) Use section 13 of your IB data book to complete the Hess cycle shown below and then use it to determine the enthalpy for the formation of methane. [3 marks]

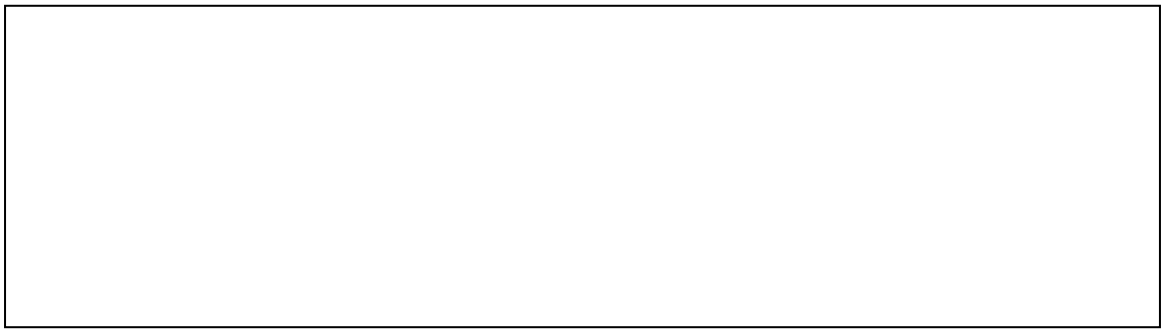


(b) The enthalpy of combustion of methane is given as -891 KJ/mol in your IB data book.

(i) Determine the enthalpy of combustion of methane using bond enthalpy values from section 11 of your data book. [2 marks]

(ii) Give one reason why these two values are not quite the same. [1 mark]





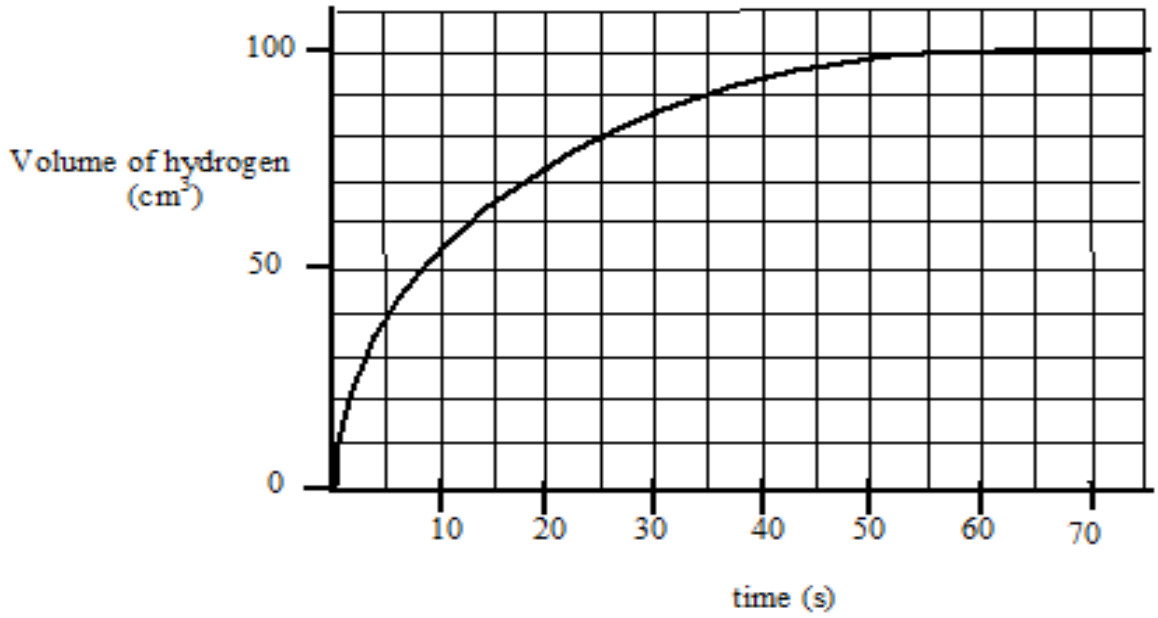
Topic 6- Kinetics

When comparing the effect of different factors on the rate of a chemical reaction, chemists are particularly interested in the initial rate of the reaction as this is when the most successful collisions are taking place.

Q6.

(a)

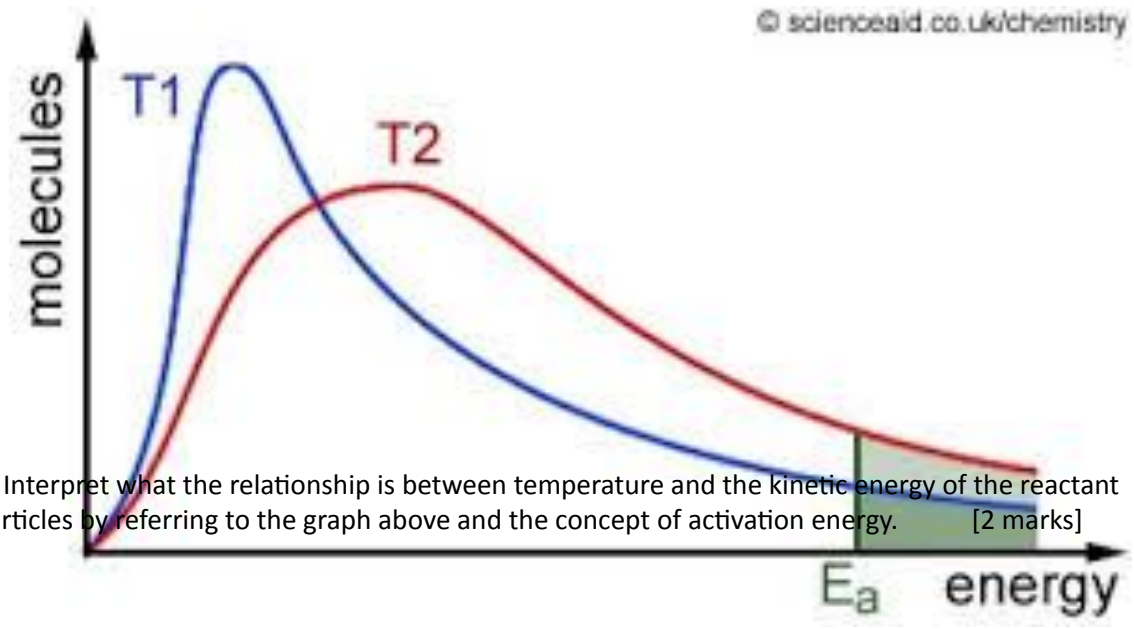
(i) Using the rate curve in the picture below, work out the initial rate for this reaction at time = 10seconds. [2marks]



(ii) To the same graph, add a trend line for the same reaction if the same amounts of reactants were used, but with a higher temperature. [1 mark]

(iii) Why would using the change in mass due to the loss of the $H_2(g)$ not be a good way to measure the rate of this reaction? [1 mark]

(b) Maxwell- Boltzmann distribution curves are often used in chemistry to illustrate the relationship between kinetic energy the number of reactant particles in a reaction.

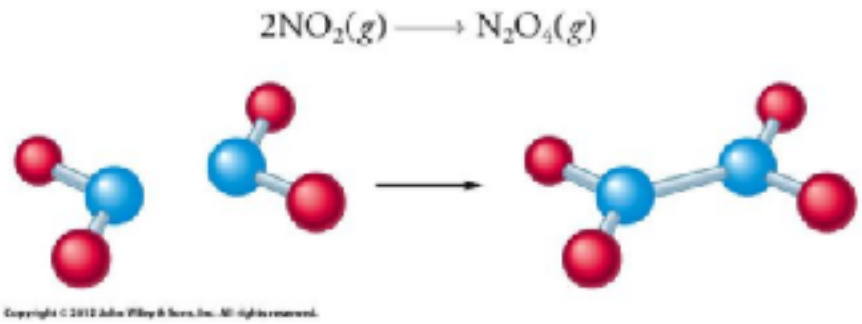


(i) Interpret what the relationship is between temperature and the kinetic energy of the reactant particles by referring to the graph above and the concept of activation energy. [2 marks]

(ii) Show the effect of adding a catalyst on this reaction by annotating the Maxwell-Boltzmann distribution curve above and justify your change to the graph using collision theory principles. [3 marks]

Topic 7- Equilibrium

A common equilibrium reaction to refer to is the one between nitrogen dioxide and dinitrogen tetroxide because of the colour change in the reaction. Nitrogen dioxide is a brown gas and dinitrogen tetroxide is a colourless gas.



Q7. (i) Write the *Kc* expression for this equilibrium [1 mark]

(ii) If the equilibrium concentration of dinitrogen tetroxide is 2 mol.dm^{-3} and the concentration of the nitrogen dioxide is 3 mol.dm^{-3}, calculate the *Kc* at a fixed temperature of 25°C. [1 mark]

(iii) Referring to Le Chatelier's principle, explain what you would observe if the temperature was increased. [3 marks]

(iv) Referring to Le Chatelier's principle, explain what you would observe if the pressure was increased. [2 marks]

(v) Explain why an increase in temperature and not the addition of a catalyst will affect the *Kc* value overall of this equilibrium. [2 marks]

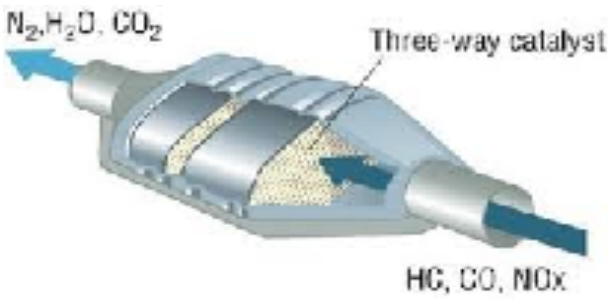
TOPIC 8- Acids & Bases

Q8.(i) Normal rain (not considered 'acid rain') has a pH of 5.65. Write an equation to illustrate why normal rain water is slightly acidic. [1 mark]

(ii) Oxides of sulfur and nitrogen are major contributors to acid rain (pH < 5.65). Write equations to show a sulfur oxide producing acid rain AND a nitrogen oxide producing acid rain. [2 marks]

(iii) Write an equation to show how one of the acids from part (ii) could corrode or damage a limestone statue with calcium carbonate in it. [1mark]

(iv) A catalytic convertor makes use of precious heavy metals like platinum, palladium and rhodium to convert NOx gasses from the incomplete combustion of hydrocarbons (such as petrol) to harmless gasses like $NO_2(g)$, $CO_2(g)$ and $H_2O(g)$.
State why this is known as heterogenous catalysis? [1 mark]



(v) Write an equation to show how a catalytic convertor could combine carbon monoxide and nitrogen monoxide to form safer exhaust gasses. [1 mark]

(vi) Why does a catalytic convertor have an extensive honeycomb structure upon which the precious metals are sprayed (refer to collision theory) [2 marks]

Topic 9- Redox processes

Q9 a) If you place an iron nail in a beaker of blue copper sulfate for about 15minutes and then remove the nail, you will observe a fresh coating of pink copper on the surface of the nail. The equation for the reaction taking place is:

$$Cu(II)SO_4(aq) + Fe(s) \rightarrow Fe(II)\ SO_4(aq) + Cu(s)$$

(i) Use the idea of the activity series of the metals to explain why this displacement reaction takes place. [2 marks]

(ii) Use oxidation numbers to explain why this can also be described as a redox reaction and identify which metal is acting as the reducing agent. [2 marks]

(iii) Write the reduction and oxidation half equations for this overall reaction. [1 mark]

b) Luigi Galvani and Alessandro Volta discovered that by separating these two metals from each other and linking them with some wires and a salt solution, a continuous electric current ('Voltaic' cell) could be generated.

(i) Draw a labelled diagram of the voltaic cell you could make using iron metal and copper metal. Include all components which are necessary to make it work. [4 marks]

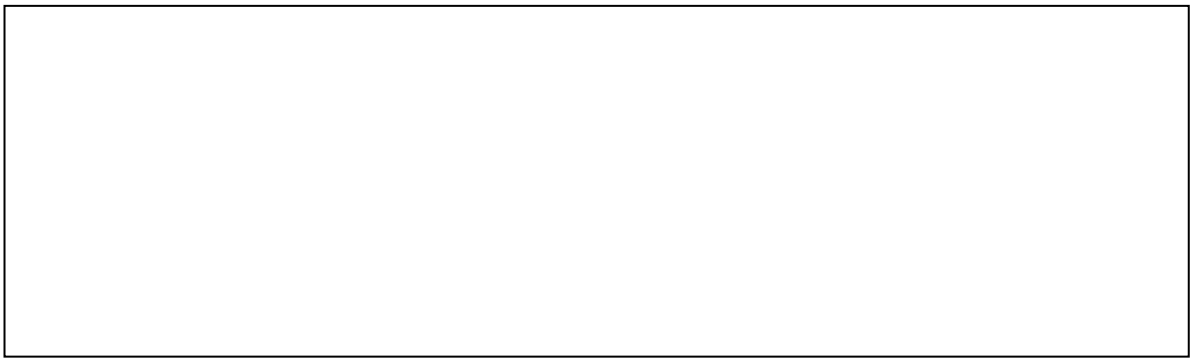
(ii) Write the cell diagram for this cell using the conventional symbols. [1 mark]

(iii) Suggest a use for this voltaic cell in everyday life. [1 mark]

Organic chemistry is often referred to as the chemistry of carbon-based compounds and so all organic compounds can be traced back to a common 'ancestor' or source which is crude oil. Because crude oil is in such short supply and because of the multitude of uses for organic compounds, a whole area of research in chemistry exists into the synthetic production of organic compounds in the lab. This is known as 'organic synthesis.'

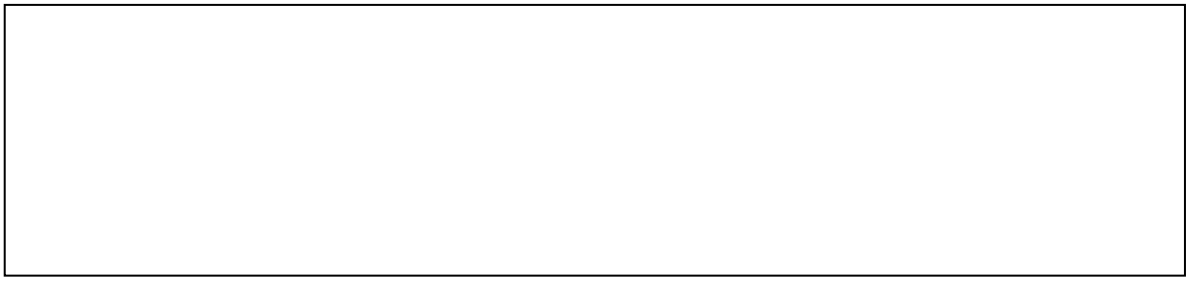
Q10. a) When crude oil is heated to high temperatures and with a metal catalyst, it can be 'cracked' into lots of ethane molecules and ethene molecules. These homologous organic families are very similar in structure, yet one is far more reactive than the other.

(i) Draw the full structural formulas for ethane and ethene. [1 mark]

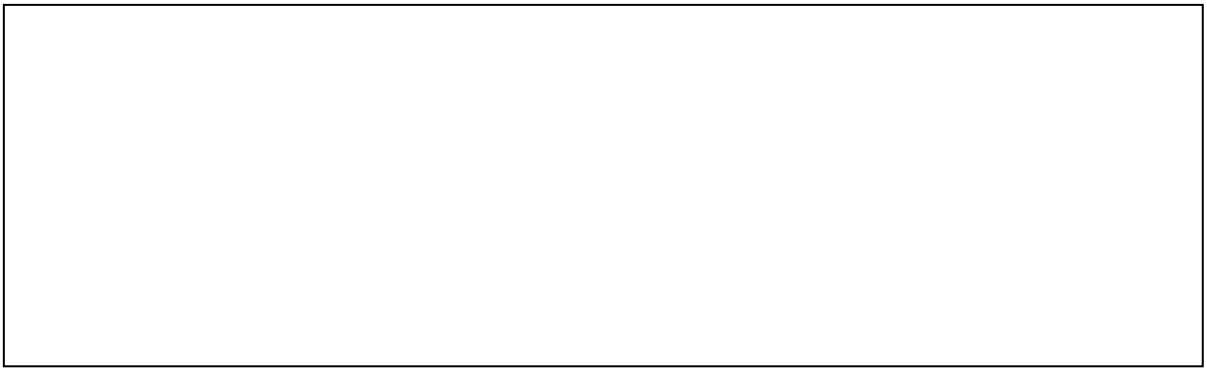


(ii) Write an equation to illustrate the chlorination of ethene. [2 marks]

(iii) The chlorination of ethane is much slower than for ethene and requires UV light. State why this is and then write an equation to illustrate the initiation step of this reaction. [2 marks]



(iv) There are 2 propagation steps to this mechanism, illustrate them using fish hook arrows correctly and explain why they are known as 'propagation' steps. [3 marks]



(v) Show the mechanism for one possible way that this reaction can terminate itself, using fish hook arrows correctly. [2 marks]

b) Clearly, alkenes such as ethene are a much better 'feedstock' chemical for organic synthesis than alkanes. In fact, there are many addition reactions which you can perform on alkenes to make many other organic families.

(i) Write an equation to show the hydration of ethene and name the product of this reaction using the primary, secondary or tertiary system. [2marks]

(ii) Oxidation of some alcohols will result in an aldehyde product and some carboxylic acid as well. Describe how the processes of distillation and reflux can help to make a pure carboxylic acid product from the alcohol (You must refer to the principles of intermolecular bonding in your answer).

[3 marks]

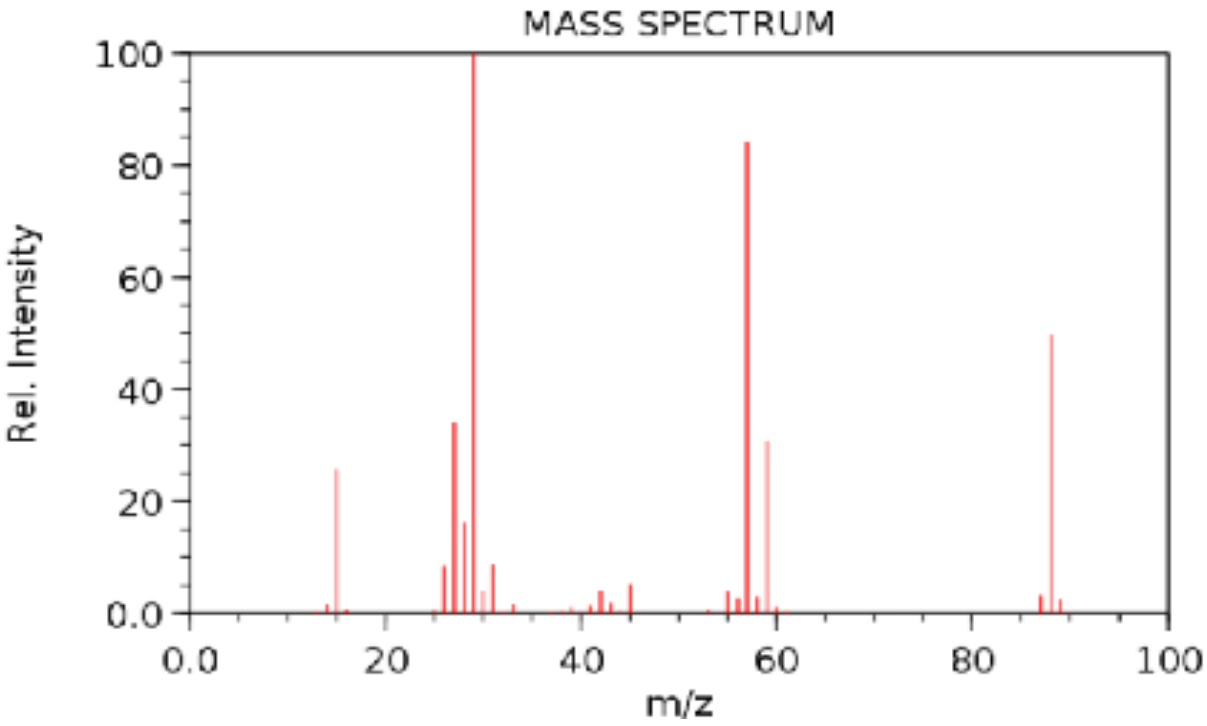
(iii) Taking the products of our syntheses in part (i) and (ii), write an equation to show how we would make an ester and explain why a strong acid is used in this reaction. [2 marks

(iv) Suggest why organic chemists, in particular, find it difficult to follow the 12 principles of green chemistry. [1 mark]

Topic 11- Measurement & Analysis.

Spectroscopy is a modern analytical technique which uses very large and expensive equipment, in combination, to determine the molecular structure and bonding of a compound. It is often employed in university research labs, forensic labs and the pilot labs at large pharmaceutical sites.

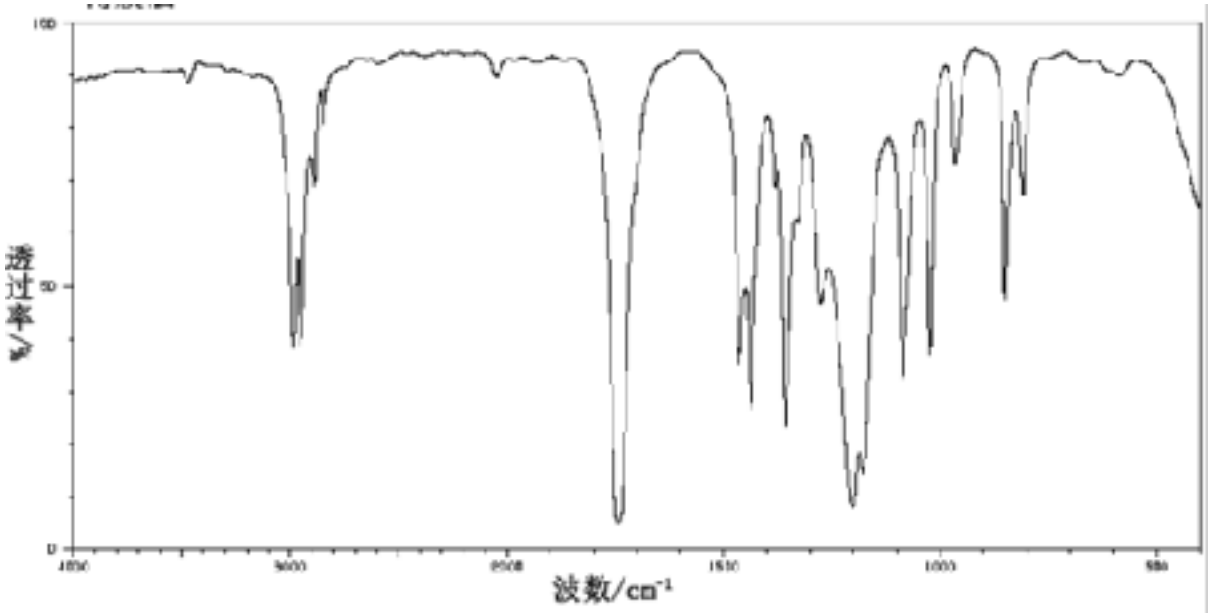
Q11. The empirical formula of a compound (X) is C_2H_4O. The mass spectrum of compound X is shown below.



(i) Use this mass spectrum to determine the molecular formula for this compound. [1 mark]

(ii) Calculate the index of hydrogen deficiency (I.H.D.) for compound X. [1mark]

The IR spectrum can be used to tell us something more about the types of functional groups which are present in compound X.



(iii) Using the IR spectrum for compound X and section 26 of your IB data book, identify the possible functional groups responsible for the significant peaks at 1200cm^{-1}, ~ 1750 cm^{-1} and ~ 3,000 cm^{-1}. [3 marks]

(iv) The final analytical technique which can be used to help us determine the identity of compound X is ^{1}H- NMR spectroscopy.

Explain what the ^{1}H-NMR spectrum shown tells you about compound X by relating to its final structural formula, and name compound X. [3 marks]