Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

WJEC CBAC

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-7	
B	8	
	9	
	10	
	11	
TOTAL MARK		

332/01

CHEMISTRY CH2

A.M. THURSDAY, 11 January 2007

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (56 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 66.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 17 may be used for rough work.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

SECTION A

Answer **all** *questions in the spaces provided.*

1. The pH of the water in a lake in Norway has been lowered by acid rain. Environmentalists have made the lake less acidic by adding powdered chalk, $CaCO_3$, to the water.

(a) State how acid rain is produced when fossil fuels are burned. [1]

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(b) Explain why powdered chalk is used for this procedure, rather than large lumps of chalk. [1]

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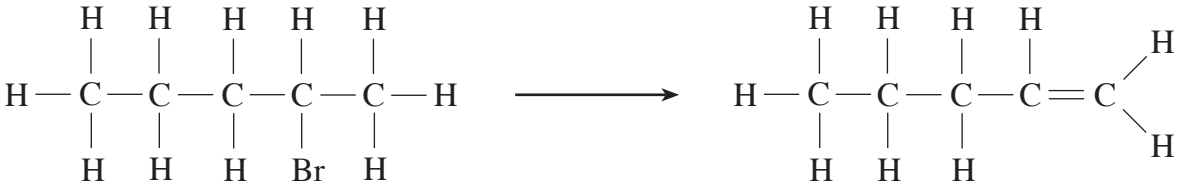
2. Under certain conditions, **Compound G** can be made from **Compound F**.



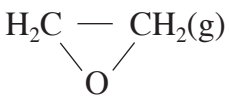
Compound F **Compound G**

(a) State the type of reaction occurring when **Compound G** is made in this way. [1]

.....

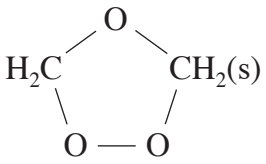
(b) Give the graphic formula of an isomer of **Compound G** that can also be formed from **Compound F** in this reaction. [1]

3. State which **one** of the following equations correctly represents the reaction occurring when measuring the enthalpy change of combustion of ethene. [1]

A $C_2H_4(g) + \frac{1}{2}O_2(g) \longrightarrow$ 

B $C_2H_4(g) + 2O_2(g) \longrightarrow 2CO(g) + 2H_2O(l)$

C $C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$

D $C_2H_4(g) + O_3(g) \longrightarrow$ 

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4. Tetrafluoroethene, C_2F_4, can be made from chlorodifluoromethane, $CHClF_2$.

$$2CHClF_2(g) \rightleftharpoons C_2F_4(g) + 2HCl(g) \qquad \Delta H = +128 \text{ kJ mol}^{-1}$$

(a) State which letter represents the conditions that will give the greatest equilibrium yield of tetrafluoroethene.

	pressure	*temperature*
A	low	low
B	low	high
C	high	low
D	high	high

..... [1]

(b) Write the expression for the equilibrium constant, K_p, in terms of partial pressures for this reaction. [1]

5. Write the **ionic** equation for the reaction that occurs when hydrochloric acid is neutralised by sodium hydroxide. [1]

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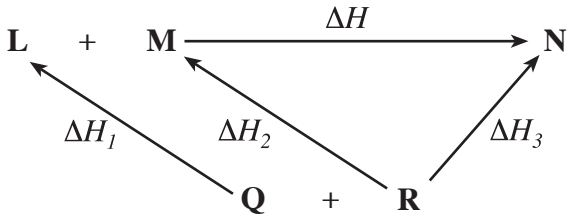
6. The equation for the ionic product of water is

$$K_w = [H^+][OH^-]$$

State the units of K_w.

..... [1]

7. Use the energy cycle below to answer the question that follows.



State which **one** of the following is a correct application of Hess's Law.

A $\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$

B $\Delta H = \Delta H_1 + \Delta H_2 - \Delta H_3$

C $\Delta H = \Delta H_3 - \Delta H_1 - \Delta H_2$

D $\Delta H = \Delta H_3 + \Delta H_1 - \Delta H_2$

..... [1]

Section A Total [10]

SECTION B

Answer **all** *questions in the spaces provided.*

8. Read the short account written below and then answer the questions that follow.

Petroleum is largely a mixture of different alkanes. These are initially separated by fractional distillation. Some larger alkanes are then cracked to give increased amounts of smaller alkanes and also alkenes.
Some vehicle fuels need larger proportions of branched alkanes so that they burn more efficiently and these are made by heating straight-chain alkanes under pressure with a platinum catalyst.

(a) Petroleum contains a large number of different straight-chain alkanes.
State how the boiling temperature of these alkanes varies with relative molecular mass. [1]

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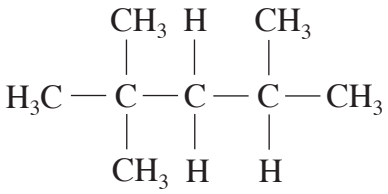
(b) By giving the **molecular** formulae, complete the equation below which represents the cracking of octane. [1]

$$\underset{\text{octane}}{C_8H_{18}} \longrightarrow \underset{\text{pentane}}{\qquad} + \underset{\text{propene}}{\qquad}$$

(c) Octane, $CH_3(CH_2)_6CH_3$, can be reformed to give **Compound A**.

$$CH_3(CH_2)_6CH_3 \longrightarrow$$



Compound A

(i) Give the systematic name of **Compound A**. [1]

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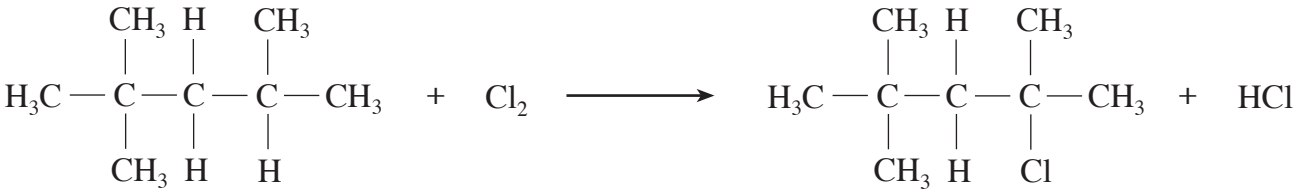
(ii) **Compound B** is one of the products when **Compound A** reacts with chlorine in the presence of ultraviolet light.



Compound A **Compound B**

The mechanism of this reaction is similar to that of methane with chlorine in the presence of ultraviolet light.

I. Give the equation for the initiation stage of this reaction. [1]

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II. During a later stage of the reaction, a carbon-containing free radical is formed. State the meaning of the term ***free radical***. [1]

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III. Suggest why another of the final products of this reaction is an alkane that contains 16 carbon atoms per molecule. [1]

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(iii) Describe, giving necessary reagents and observations, how you would detect the presence of chlorine in **Compound B**. [2]

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(d) Propene, one product of the cracking of octane, reacts with hydrogen bromide to give a bromopropane.

$$C_3H_6 + HBr \longrightarrow C_3H_7Br$$

(i) Classify the type of reaction mechanism that is occurring in this reaction. [1]

.....

(ii) Give the reaction mechanism for the production of the major product in this reaction.
You should use **curly arrows** and show **partial** and **full charges** in your response. [4]

(iii) Give a reason for your choice of bromopropane isomer. [1]

.....

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Total [14]

9. *(a)* The catalytic hydrogenation of alkenes is an important reaction for the production of fats used in making margarine.

Some unsaturated fats are derived from linolenic acid, which has the following formula.

$$CH_3CH_2CH = CHCH_2CH = CHCH_2CH = CH(CH_2)_7COOH$$

Linolenic acid

(i) State the number of moles of hydrogen gas necessary to react with 1 mole of linolenic acid to produce stearic acid, which has the following formula. [1]

$$CH_3(CH_2)_{16}COOH$$

Stearic acid

.....

(ii) Part of the formula of linolenic acid is shown below.

$$- CH_2CH = CH(CH_2)_7COOH$$

Use this formula to help you **explain** whether linolenic acid can exist as cis-trans isomers. [2]

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(iii) Describe a test, giving starting reagent(s) and observations, to distinguish between linolenic acid and stearic acid, giving the result of your test for **each** compound.
You should assume that both acids are in a suitable solution.

Reagent(s) ..... [1]

Observations .....

..... [1]

(iv) Describe a chemical test (other than by using indicators), stating reagent(s) and observations, to distinguish between stearic acid, $CH_3(CH_2)_{16}COOH$, and the alkane octadecane, $CH_3(CH_2)_{16}CH_3$. Give the result of the test for **both** compounds.
You should assume that both compounds are in a suitable solution.

Reagent(s) ..... [1]

Observations .....

..... [1]

(b) The standard molar enthalpy change of formation of stearic acid, $\Delta H_f^{\ominus}$, is -941 kJ mol^{-1}.
Define ***standard conditions*** in terms of temperature and pressure.

Temperature ..... [1]

Pressure ..... [1]

(c) Organic acids derived from fats are described as weak acids.

(i) In aqueous solution, an organic acid, R-COOH, partly dissociates into ions.

$$\text{R-COOH(aq)} \rightleftharpoons \text{R-COO}^-\text{(aq)} + \text{H}^+\text{(aq)}$$

Write an expression for the acid dissociation constant, K_a, of the organic acid. [1]

(ii) Another organic acid, R′-COOH, is a stronger acid than R-COOH.
State which one has the larger K_a value, giving a reason for your answer. [2]

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Total [12]

10. *(a)* Iodine stains on clothes can be removed by washing with a solution containing thiosulphate ions, $S_2O_3^{2-}$. The following reaction occurs.

$$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$$

(i) The rate of this reaction depends on the concentration of thiosulphate ions in the solution used.
Explain, in terms of the collision theory, why the stain is removed faster if the solution contains a higher concentration of thiosulphate ions. [1]

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(ii) To follow the rate of this reaction, an aqueous solution containing thiosulphate ions was added to an aqueous solution containing iodine.
Samples were removed automatically every three seconds and the concentration of the thiosulphate ions was measured.
At the start of the reaction, the concentration of thiosulphate ions was 0·0100 mol dm^{-3}. After three seconds, the concentration of the thiosulphate ions had fallen to 0·0076 mol dm^{-3}.

I. Calculate the rate of decrease of the thiosulphate concentration, in mol dm^{-3} s^{-1}. [1]

..... mol dm^{-3} s^{-1}

II. Use your answer to I. and the given ionic equation to deduce the change in concentration of aqueous iodine over the first three seconds, in mol dm^{-3}. [1]

..... mol dm^{-3}

(b) Perspiration stains in clothes are partly due to the presence of butanoic acid, $CH_3CH_2CH_2COOH$.
Alkaline solutions, often containing sodium carbonate, are used to neutralise this acidity.
The equation for the reaction between butanoic acid and sodium carbonate is shown below.

$$2CH_3CH_2CH_2COOH(aq) + Na_2CO_3(aq) \longrightarrow 2CH_3CH_2CH_2COONa(aq) + CO_2(g) + H_2O(l)$$

(i) Briefly describe a method, giving essential details, for following the rate of the reaction between aqueous butanoic acid and aqueous sodium carbonate. [2]

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(ii) In another experiment, a student found that 24·2 cm^3 of a sodium carbonate solution of concentration 0·0500 mol dm^{-3} exactly neutralised 0·245 g of impure butanoic acid. Calculate, giving your answers to three significant figures,

I. the number of moles of sodium carbonate used, [1]

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II. the number of moles of pure butanoic acid present, [1]

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III. the mass of pure butanoic acid present, [1]

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IV. the percentage of pure butanoic acid in the sample of mass 0·245 g [1]

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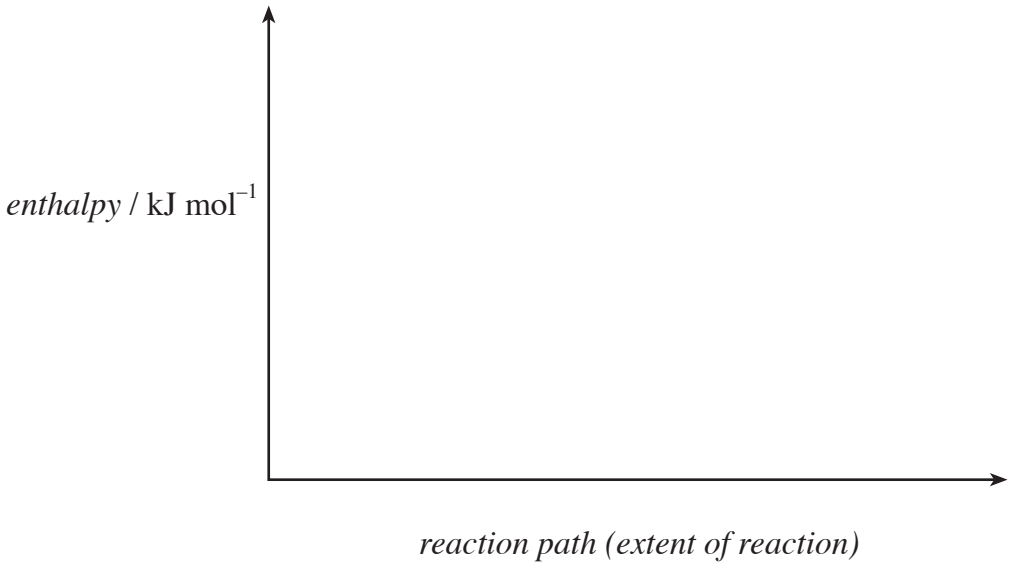
(c) But-1-ene is produced when butane is heated and passed over a catalyst.

$$CH_3CH_2CH_2CH_3(g) \longrightarrow CH_3CH_2CH=CH_2(g) + H_2(g) \quad \Delta H = +127 \text{ kJ mol}^{-1}$$

(i) Use the axes below to draw and label a reaction profile for the above reaction when it is

I. uncatalysed,

II. catalysed. [2]



(ii) State the value for the enthalpy change of reaction, in kJ mol^{-1}, for the reverse reaction. Give a reason for your answer. [2]

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(iii) When average bond energy values are used to calculate the enthalpy change of reaction, the value is different from that given above.

Explain why these two values are not the same. [1]

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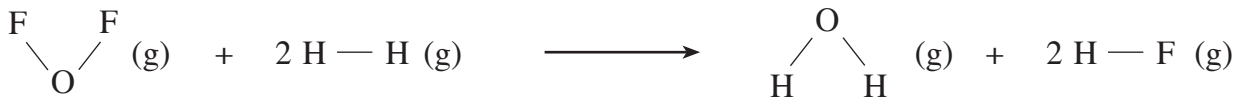
Total [14]

11. *(a)* Difluorine oxide, a dangerous yellow gas, reacts with hydrogen to produce steam and gaseous hydrogen fluoride.



Use the table of bond enthalpies to calculate the enthalpy change, ΔH, for this reaction. [2]

Bond	*Bond enthalpy* / kJ mol^{-1}
F — O	222
H — H	436
H — O	464
H — F	568

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(b) A number of organic compounds containing halogens, including CFCs, are known to cause environmental damage and, as a result, the use of these compounds has been reduced.
The manufacturers of refrigerators and freezers have stopped using CF_2Cl_2 and now use CH_2FCH_3.
Bromotrifluoromethane, CF_3Br, also causes the same serious environmental damage and a safer alternative is the less stable iodotrifluoromethane, CF_3I.
These problems are caused by homolytic fission in the upper atmosphere, producing species which act as a catalyst.
Bond energies are important when considering which materials are safer to use.

Bond	*Average bond enthalpy* / kJ mol^{-1}
C — I	234
C — Br	290
C — Cl	346
C — F	467

Use the given information to outline the chemistry involved when these compounds cause environmental damage.

Your answer should include

- a description of the environmental problem and its effect on plants and animals
- what is meant by homolytic fission
- the relevance of bond energies to environmental damage
- the breaking of which bonds causes environmental damage
- a suggestion as to why iodotrifluoromethane is a safer alternative to bromotrifluoromethane. [6]

(c) Give an example of how a chemical discovery has made a positive contribution to society.
Your answer should name both the discovery and the effect it has had. [2]

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(d) A chlorofluorocarbon (CFC), **Compound T**, contains the following percentages by mass; C 15·7%; H 0·66%; Cl 46·4% and the remainder is fluorine.
It contains two carbon atoms per molecule.
Find the empirical formula of **Compound T** and hence its molecular formula.
Draw a possible graphic formula for **Compound T**. [3]

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(e) Catalysts are used extensively in industry, for example, platinum in the reforming of straight-chain alkanes.

(i) State how catalysts are able to speed up chemical reactions. [1]

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(ii) Explain why catalysts do not affect the percentage equilibrium yield. [1]

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(iii) Give another example of the use of a heterogeneous catalyst, stating the process and the catalyst used. [1]

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Total [16]

Section B Total [56]

Rough Work