Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2009
Advanced Subsidiary Examination

CHEMISTRY **CHM2**
Unit 2 Foundation Physical and Inorganic Chemistry

Wednesday 3 June 2009 9.00 am to 10.00 am

For this paper you must have
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a calculator.

Time allowed: 1 hour

For Examiner's Use			
Question	Mark	Question	Mark
1		4	
2		5	
3			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. **Answers written in margins or on blank pages will not be marked.**
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- The Periodic Table/Data Sheet is provided as an insert.

Information
- The maximum mark for this paper is 60.
- The marks for each question are shown in brackets.
- You are expected to use a calculator where appropriate.
- Write your answers to the question in **Section B** in continuous prose, where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

Advice
- You are advised to spend about 45 minutes on **Section A** and about 15 minutes on **Section B**.

SECTION A

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

1 (a) Write an equation for the reaction in which the enthalpy change is the standard enthalpy of formation of gaseous methoxymethane, CH_3OCH_3

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(2 marks)

1 (b) Define the term *standard enthalpy of combustion*.

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(3 marks)

1 (c) Methoxymethane burns completely in air according to the following equation.

$$CH_3OCH_3(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$$

1 (c) (i) Use the standard enthalpies of formation given in the table below to calculate a value for the standard enthalpy of combustion of methoxymethane.

Substance	$CH_3OCH_3(g)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	–185	0	–394	–286

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(3 marks)

1 (c) (ii) State why the standard enthalpy of formation of oxygen is zero.

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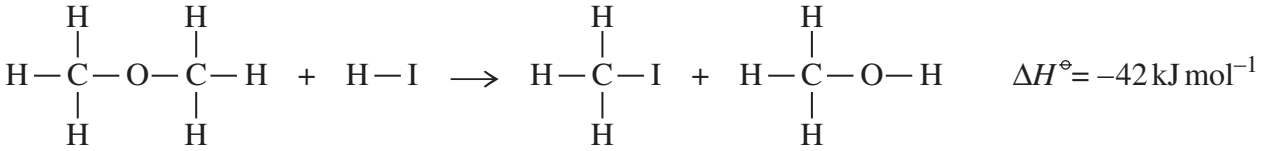
(1 mark)

1 (d) Methoxymethane reacts with hydrogen iodide as shown in the following equation.



1 (d) (i) Use the information from the equation above and the mean bond enthalpies from the table below to calculate a value for the bond enthalpy of the O—H bond.

Bond	C—H	C—O	H—I	C—I
Mean bond enthalpy / kJ mol^{-1}	412	360	299	238

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(3 marks)

1 (d) (ii) Suggest which bond is most likely to break first in a collision between a methoxymethane molecule and a hydrogen iodide molecule.

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(1 mark)

13

Turn over ▶

2 (a) When silver nitrate solution is added to a mixture containing two different halide ions in solution, two different precipitates, **R** and **S**, are formed. When concentrated ammonia solution is then added, **R** remains as a precipitate and **S** dissolves completely.

2 (a) (i) Identify the halide ion in **R**.

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(1 mark)

2 (a) (ii) Identify a possible halide ion in **S**.

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(1 mark)

2 (a) (iii) Write an ionic equation for the formation of the precipitate **R** from silver nitrate.

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(1 mark)

2 (b) When concentrated sulphuric acid is added to solid sodium chloride a reaction occurs in which misty fumes are formed.

2 (b) (i) Write an equation for this reaction.

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(1 mark)

2 (b) (ii) State the role of sulphuric acid in this reaction.

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(1 mark)

2 (c) When concentrated sulphuric acid is added to solid sodium bromide, a redox reaction occurs. A mixture of gases, including sulphur dioxide, is formed.

2 (c) (i) State the oxidation state of sulphur in sulphuric acid and in sulphur dioxide.

Oxidation state of sulphur in sulphuric acid .....

Oxidation state of sulphur in sulphur dioxide .....

(2 marks)

2 (c) (ii) Write an equation for the redox reaction between concentrated sulphuric acid and solid sodium bromide. State the role of sulphuric acid in this reaction.

Equation .....

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Role of sulphuric acid .....

(3 marks)

2 (d) When concentrated sulphuric acid is added to solid sodium iodide a redox reaction occurs to produce sulphur dioxide. Two other reduction products are formed.

Identify these two other reduction products. In each case, state an observation that would confirm the identity of the product.

Reduction product 1 .....

Observation .....

Reduction product 2 .....

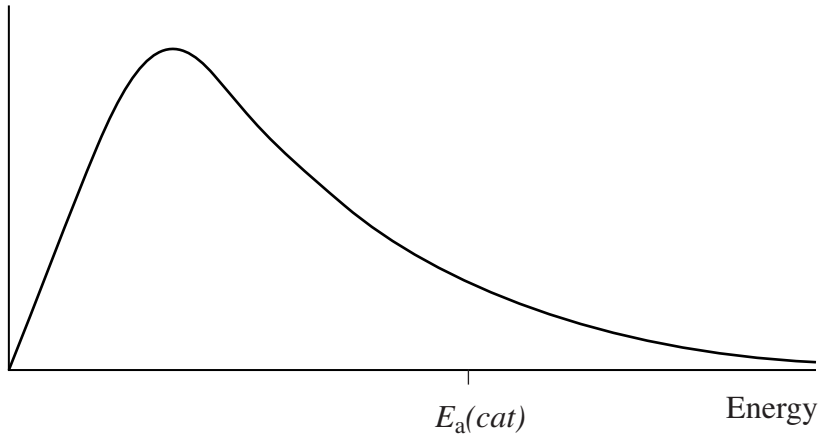
Observation .....

(4 marks)

14

3 The diagram below shows a Maxwell–Boltzmann distribution of molecular energies for a mixture of gases.

$E_a(cat)$ is the activation energy for the catalysed reaction between the gases in the mixture.



3 (a) On the diagram above, label the vertical axis. *(1 mark)*

3 (b) (i) State the meaning of the term *activation energy*.

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(2 marks)

3 (b) (ii) On the energy axis in the diagram above, mark with an **X** a possible activation energy for the uncatalysed reaction. *(1 mark)*

3 (b) (iii) Explain why some reactions are slow without a catalyst.

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(2 marks)

3 (c) State and explain the effect on the rate of a reaction involving gases when the volume of the container is decreased but the number of gas particles and the temperature stay the same.

Effect .....

Explanation .....

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(3 marks)

9

4 Consider the following equations which show reversible reactions.

Reaction **1** $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H^{\ominus} = -900\,kJ\,mol^{-1}$

Reaction **2** $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H^{\ominus} = -91\,kJ\,mol^{-1}$

4 (a) In industry these reactions are carried out in the presence of catalysts. A platinum catalyst is used in Reaction **1** and a copper catalyst is used in Reaction **2**.

4 (a) (i) Give **one** reason why a metal catalyst is often used in the form of a gauze or a powder.

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(1 mark)

4 (a) (ii) State and explain the effect on the equilibrium yield of a reaction when a catalyst is used.

Effect on equilibrium yield .....

Explanation .....

.....

(2 marks)

4 (b) State and explain which of the above reactions will give an increase in the equilibrium yield of product when the overall pressure is increased at constant temperature.

Reaction .....

Explanation .....

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(3 marks)

4 (c) State and explain the effect on the equilibrium yield of product when the temperature is increased in Reaction **1** at constant pressure.

Effect .....

Explanation .....

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(3 marks)

9

Turn over ▶

SECTION B

Answer Question **5** in the spaces provided.

5 Titanium and aluminium are both extracted from their oxides. Both extraction processes require high temperatures.

5 (a) Outline the essential features of the extraction process used to obtain titanium from titanium(IV) oxide. Illustrate your answer with equations.

Give **three** reasons why the manufacture of pure titanium is expensive.

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(7 marks)

5 (b) There has been a great deal of research into finding cheaper methods of extracting pure titanium but so far none has been commercially successful.

Give a reason why a cheaper method, using direct reduction of titanium(IV) oxide by carbon, has been unsuccessful.

State **one** property of titanium which makes it more useful than aluminium.

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(2 marks)

Question 5 continues on the next page

5 (c) In the presence of cryolite, aluminium is extracted from its oxide by electrolysis. State the essential condition for this electrolysis and write half-equations for the reactions occurring at the electrodes. Give the main reason why this process is expensive.

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(4 marks)

5 (d) Give **two** reasons why recycling aluminium is environmentally beneficial.

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(2 marks)

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Gas constant $R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

Table 1
Proton n.m.r. chemical shift data

Type of proton	δ/ppm
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

Table 2
Infra-red absorption data

Bond	Wavenumber/cm^{-1}
C—H	2850–3300
C—C	750–1100
C═C	1620–1680
C═O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

The Periodic Table of the Elements

■ The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

I	II										III	IV	V	VI	VII	0
1.0 **H** Hydrogen 1																4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4										10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12										27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	98.9 **Tc** Technetium 43	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	138.9 **La** Lanthanum 57 *	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.9 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	210.0 **Po** Polonium 84	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	144.9 **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	237.0 **Np** Neptunium 93	239.1 **Pu** Plutonium 94	243.1 **Am** Americium 95	247.1 **Cm** Curium 96	247.1 **Bk** Berkelium 97	252.1 **Cf** Californium 98	(252) **Es** Einsteinium 99	(257) **Fm** Fermium 100	(258) **Md** Mendelevium 101	(259) **No** Nobelium 102	(260) **Lr** Lawrencium 103

*** 58 – 71** Lanthanides

† 90 – 103 Actinides