Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 4 June 2008 9.00 am to 10.00 am

For this paper you must have
- 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 blank pages will not be marked.
- Your answers to the parts of **Section B** should be on the pages indicated.
- 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 Metal extraction involves reduction reactions using more reactive metals, hydrogen, carbon or electrolysis.

1 (a) Titanium can be extracted from titanium(IV) chloride by reduction using either sodium or hydrogen.

1 (a) (i) Write an equation for each of these reduction reactions.

Reaction with sodium .....

Reaction with hydrogen .....

(2 marks)

1 (a) (ii) Give one reason, other than cost, why hydrogen is not the preferred reducing agent for the extraction of titanium.

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(1 mark)

1 (b) Suggest why carbon is not a suitable reducing agent for the extraction of titanium.

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(1 mark)

1 (c) Carbon is a reducing agent in the extraction of iron from impure iron(III) oxide. Slag is a by-product of this process.

1 (c) (i) Write an equation for the reduction of iron(III) oxide with carbon. State one condition necessary for this reaction to occur.

Equation .....

Condition .....

(2 marks)

1 (c) (ii) Give the name of the raw material used to remove the silicon dioxide impurity from the iron(III) oxide. Write equation(s) to show how this raw material reacts to form slag in the extraction process.

Raw material .....

Equation(s) .....

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(3 marks)

1 (c) (iii) State one use of slag.

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(1 mark)

1 (d) Carbon is used for the electrodes in the extraction of aluminium from aluminium oxide. Cryolite is used in this extraction process.

1 (d) (i) Write a half-equation for each of the electrode reactions.

Half-equation 1 .....

Half-equation 2 .....

(2 marks)

1 (d) (ii) Give one reason why cryolite is used.

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(1 mark)

1 (e) Give the major reason why recycling of aluminium is economically viable.

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(1 mark)

14

Turn over for the next question

2 Enthalpy of combustion and bond enthalpy data can be used, with Hess's Law, to calculate enthalpy changes for other reactions.

2 (a) Define the term *standard enthalpy of combustion*.

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(3 marks)

2 (b) State *Hess's Law*.

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(1 mark)

2 (c) The equation below shows the formation of buta-1,3-diene, C_4H_6

$$4C(s) + 3H_2(g) \longrightarrow C_4H_6(g)$$

Use the following data to calculate the standard enthalpy of formation of buta-1,3-diene.

$$C(s) + O_2(g) \longrightarrow CO_2(g) \qquad \Delta H^{\ominus} = -394\,kJ\,mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(l) \qquad \Delta H^{\ominus} = -286\,kJ\,mol^{-1}$$

$$C_4H_6(g) + 5\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 3H_2O(l) \qquad \Delta H^{\ominus} = -2542\,kJ\,mol^{-1}$$

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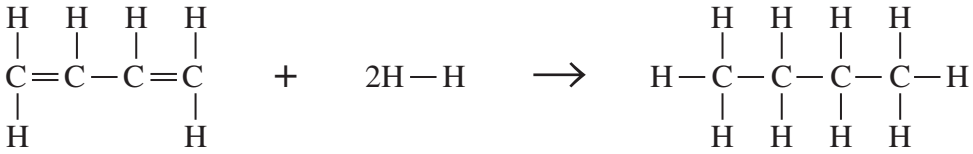
(3 marks)

2 (d) Buta-1,3-diene reacts with hydrogen to form butane according to the following equation.



The standard enthalpy change for this reaction, $\Delta H^{\ominus} = -240\,\text{kJ mol}^{-1}$

Bond	C−C	H−H	C−H
Mean bond enthalpy/kJ mol^{-1}	348	436	412

Use the data given above to calculate a bond enthalpy value for the C=C bond.

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(3 marks)

10

Turn over for the next question

3 (a) State, in terms of electrons, what happens to an oxidising agent in a redox reaction.

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(1 mark)

3 (b) When concentrated sulphuric acid is added to solid sodium bromide, the acid reacts with Br^- ions to form SO_2 and Br_2

3 (b) (i) Write a half-equation to show how SO_2 is formed from sulphuric acid.

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(1 mark)

3 (b) (ii) Write a half-equation to show how Br_2 is formed from Br^- ions.

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(1 mark)

3 (b) (iii) Hence write an overall equation for the reaction of Br^- ions with sulphuric acid.

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(1 mark)

3 (b) (iv) Deduce the role of Br^- ions in this reaction.

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(1 mark)

3 (c) (i) Identify a halide ion that does **not** produce SO_2 when the solid sodium halide reacts with concentrated sulphuric acid.

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(1 mark)

3 (c) (ii) Write an equation for the reaction of concentrated sulphuric acid with the halide ion that you identified in part (c)(i).

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(1 mark)

3 (c) (iii) State the role of sulphuric acid in this reaction.

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(1 mark)

3 (d) When chlorine gas is bubbled into a solution of sodium bromide the following reaction occurs.

$$Cl_2(g) + 2NaBr(aq) \longrightarrow 2NaCl(aq) + Br_2(aq)$$

Deduce the role of Cl_2 in this reaction

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(1 mark)

3 (e) In aqueous solution, silver nitrate and ammonia can be used to test for halide ions.

3 (e) (i) Identify a halide ion that reacts with silver nitrate solution to produce a precipitate which dissolves completely in dilute aqueous ammonia.

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(1 mark)

3 (e) (ii) Write an **ionic** equation for the reaction between silver nitrate and the halide ion you identified in part (e)(i).

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(1 mark)

3 (e) (iii) Identify the halide ion which cannot be detected using silver nitrate.

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(1 mark)

12

4 The hydrogen used in the Haber process is made by the following reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +206\,kJ\,mol^{-1}$$

4 (a) Explain why the concentrations of the reactants and the products remain constant when equilibrium is established.

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(1 mark)

4 (b) A high temperature of over 1000 °C is used in the production of hydrogen by this reaction.

4 (b) (i) Explain why a high temperature is needed to produce a high equilibrium yield of hydrogen.

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(2 marks)

4 (b) (ii) Give one disadvantage of using temperatures much higher than 1000 °C.

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(1 mark)

4 (c) State and explain how the overall pressure must be changed to produce an increase in the equilibrium yield of hydrogen.

Change in pressure .....

Explanation .....

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(3 marks)

4 (d) Explain why the addition of a catalyst has no effect on the equilibrium yield of hydrogen in the reaction.

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(2 marks)

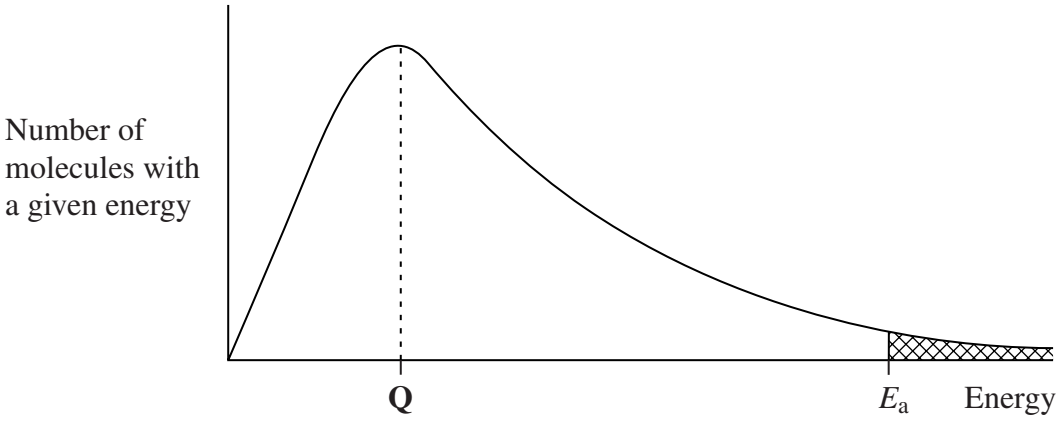
9

Turn over for the next question

SECTION B

Answer the question below in the space provided on pages 11 to 14 of this booklet.
You should answer each part of the question on the separate page indicated.
Each part of the question is reprinted at the top of the page.

5 The curve shows the distribution of molecular energies for a mixture of gases which react together. The activation energy for the reaction is E_a



5 (a) Explain what is meant by the term *activation energy*.

(2 marks)

5 (b) State what **Q** represents and what the total area under the curve represents.
Explain why the curve starts at the origin and why the shaded area is very small.

(4 marks)

5 (c) Describe how the shape of the curve, the area under the curve, the value of E_a and the value of **Q** change if the temperature is increased.
Explain why a small increase in temperature results in a large increase in the rate of a reaction.

(7 marks)

5 (d) Explain why a catalyst increases the rate of a reaction.

(2 marks)

END OF QUESTIONS

5 (a) Explain what is meant by the term *activation energy*.

Write your answer to Question 5(a) on this page.

5 (b) State what **Q** represents and what the total area under the curve represents.
Explain why the curve starts at the origin and why the shaded area is very small.

Write your answer to Question 5(b) on this page.

5 (c) Describe how the shape of the curve, the area under the curve, the value of E_a and the value of **Q** change if the temperature is increased.
Explain why a small increase in temperature results in a large increase in the rate of a reaction.

Write your answer to Question 5(c) on this page.

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5 (d) Explain why a catalyst increases the rate of a reaction.

Write your answer to Question 5(d) on this page.

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ANSWER IN THE SPACES PROVIDED

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

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