Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Wednesday 6 June 2007 9.00 am to 10.00 am

For this paper you must have
- a calculator.

Time allowed: 1 hour

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer questions in **Section A** and **Section B** in the spaces provided.
- 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 on pages 3 and 4. Detach this perforated sheet at the start of the examination.

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**.

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

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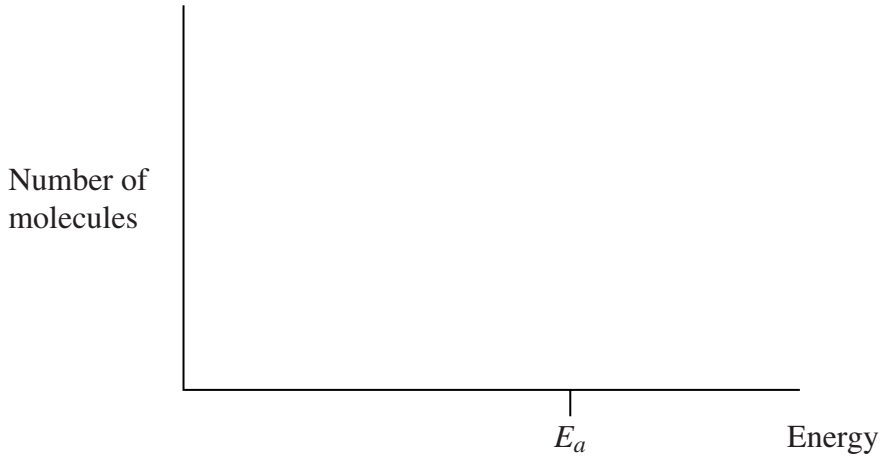
SECTION A

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

1 (a) (i) On the axes below, draw a Maxwell-Boltzmann distribution of molecular energies for a gas at temperature *T*.
E_a is the activation energy for a reaction involving this gas.



(2 marks)

(ii) State the meaning of the term *activation energy*.

.....

.....

(2 marks)

(iii) Shade on the graph the area that represents the number of molecules which can react at temperature *T*.

(1 mark)

(b) (i) State the effect on the activation energy of increasing the temperature.

.....

(1 mark)

(ii) Explain why reactions involving gases become faster as the temperature increases.

.....

.....

(2 marks)

(c) A mixture of gases is allowed to react in the presence of a catalyst.
State and explain the effect of a catalyst on the rate of this reaction.

Effect .....

Explanation .....

.....

(3 marks)

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

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

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2 (a) The extraction of iron involves the reduction of iron(III) oxide, Fe_2O_3, in the Blast Furnace by a reducing agent.

(i) In terms of electrons, state what is meant by *reduction* and *reducing agent*.

Reduction .....

Reducing agent .....

(ii) Identify a reducing agent that can reduce Fe_2O_3 to iron in the Blast Furnace. Write an equation for the reaction between Fe_2O_3 and the reducing agent you have stated.

Reducing agent .....

Equation .....

(iii) Give one essential condition needed for this reduction.

.....

(5 marks)

(b) Molten iron obtained from the Blast Furnace contains carbon as an impurity. Explain how this impurity is removed.

.....

.....

.....

(2 marks)

(c) (i) Titanium is extracted from titanium(IV) oxide, TiO_2, in a two-stage process. Write equations for the reaction occurring in stage 1 and stage 2 of this extraction.

Equation for stage 1 .....

Equation for stage 2 .....

(ii) Give one essential condition, other than temperature, for the second stage, and state why it is necessary.

Condition .....

Reason .....

(4 marks)

(d) Give two reasons why titanium is expensive to extract.

Reason 1 .....

Reason 2 .....

(2 marks)

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3 (a) Define the term *standard enthalpy of formation*.

.....

.....

.....

(3 marks)

(b) Write an equation, including state symbols, for the reaction with an enthalpy change equal to the standard enthalpy of formation of liquid nitric acid, HNO_3

.....

(2 marks)

(c) State Hess's Law.

.....

.....

(1 mark)

(d) Nitric acid can be made by reacting water, nitrogen dioxide and oxygen according to the following equation.

$$H_2O(l) + 2NO_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow 2HNO_3(l) \qquad \Delta H^{\ominus} = -128\,kJ\,mol^{-1}$$

Some standard enthalpies of formation, $\Delta H_f^{\ominus}$, are given in the table below.

Substance	$H_2O(l)$	$NO_2(g)$	$O_2(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	– 286	+34	0

(i) State why the standard enthalpy of formation of $O_2(g)$ is zero.

.....

(1 mark)

(ii) Use the data above to calculate a value for the standard enthalpy of formation of nitric acid.

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(4 marks)

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4 When nitrogen monoxide reacts with oxygen, a dynamic equilibrium is established.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H^{\ominus} = -115\,kJ\,mol^{-1}$$

(a) State what is meant by *dynamic equilibrium*.

.....

.....

.....

(2 marks)

(b) State and explain how the total pressure in this equilibrium reaction should be changed to give a higher equilibrium yield of NO_2

Change in pressure .....

Explanation .....

.....

(3 marks)

(c) State and explain the effect of an increase in temperature on the yield of NO_2 in this equilibrium reaction.

Effect .....

Explanation .....

.....

(3 marks)

(d) Deduce the oxidation state of nitrogen in NO_3^- and in NO_2^+

NO_3^- .....

NO_2^+ .....

(2 marks)

10

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SECTION B

Answer **question 5** in the space provided on pages 8 to 12 of this booklet.

5 (a) State the trend in the reducing ability of the halide ions from fluoride to iodide.

(1 mark)

(b) Concentrated sulphuric acid reacts with solid potassium iodide to form a mixture of products. These products include sulphur dioxide and iodine.

Write half-equations for the formation of iodine from iodide ions, and for the formation of sulphur dioxide from sulphuric acid. Hence write an overall equation for the formation of these products from iodide ions and sulphuric acid.

Identify one other reduction product formed in the reaction between sulphuric acid and solid potassium iodide.

(4 marks)

(c) State what you would observe when aqueous bromine reacts with a solution of potassium iodide. Write an equation for the reaction.
State the role of bromine in the reaction.

(3 marks)

(d) Give a reagent which could be used to distinguish between separate solutions of potassium bromide and potassium iodide. State what would be observed when this reagent is added to each of the separate solutions of potassium bromide and potassium iodide. Write an equation for **one** of the reactions.
Identify a reagent which could be added to the mixtures from the first test to confirm the identity of the halide ions. State what would be observed in each case.

(7 marks)

END OF QUESTIONS

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