Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
January 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Thursday 11 January 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 the 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 questions 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			
6			
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) Explain the meaning of the term *enthalpy change* of a reaction.

.....

.....

(2 marks)

(b) Write the equation for the reaction for which the enthalpy change is the standard enthalpy of formation of the gas nitrous oxide, N_2O

.....

(1 mark)

(c) The equation for the formation of nitrogen trifluoride is given below.

$$\tfrac{1}{2}N_2(g) + 1\tfrac{1}{2}F_2(g) + \longrightarrow NF_3(g)$$

(i) Using the mean bond enthalpy values given in the table, calculate a value for the enthalpy of formation of nitrogen trifluoride.

Bond	N−F	N≡N	F−F
Mean bond enthalpy / kJ mol^{-1}	278	945	159

.....

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(ii) A data book value for the enthalpy of formation of nitrogen trifluoride is –114 kJ mol^{-1}. Give one reason why the answer you have calculated in part (c)(i) is different from this data book value.

.....

.....

(4 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.

Key

relative atomic mass — 6.9
Li
Lithium
atomic number — 3

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 †															

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 J K^{-1} 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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(d) Some standard enthalpies of formation are given in the table below.

Substance	$NH_3(g)$	$F_2(g)$	$NF_3(g)$	$NH_4F(s)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	–46	0	–114	–467

(i) State why the enthalpy of formation of fluorine is zero.

.....

(ii) Use these data to calculate the enthalpy change for the following reaction.

$$4NH_3(g) + 3F_2(g) \longrightarrow NF_3(g) + 3NH_4F(s)$$

.....

.....

.....

.....

(4 marks)

11

Turn over for the next question

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2 The compound HClO decomposes according to the following equation.

$$5HClO(aq) \longrightarrow 2Cl_2(g) + H^+(aq) + ClO_3^-(aq) + 2H_2O(l)$$

(a) (i) Deduce the oxidation states of chlorine in the following species

HClO .....

Cl_2 .....

ClO_3^- .....

(ii) Comment on the redox behaviour of HClO in this reaction.

.....

.....

(4 marks)

(b) (i) Write the half-equation to show how HClO is converted, in acid solution, into chlorine gas.

.....

(ii) Write the half-equation to show how aqueous HClO is converted into ClO_3^- ions and H^+ ions.

.....

(2 marks)

6

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3 (a) (i) State the trend in oxidising ability of the halogens from fluorine to iodine.

.....

(ii) Write an equation to show how chlorine reacts with aqueous potassium bromide.

.....

(2 marks)

(b) Use the following information to identify the species **J**, **K**, **L**, **M**, **N** and **Q**.

When silver nitrate solution is added to a solution of sodium halide **J**, a colourless solution remains and no precipitate is formed.

When silver nitrate solution is added to a solution of a sodium halide **K**, a yellow solid is formed.

When concentrated sulphuric acid is added to solid sodium halide **L**, a brown gas **M** and two colourless gases **N** and **Q** are formed. Gases **N** and **Q** both dissolve in water to form acidic solutions.

*Identity of **J*** .....

*Identity of **K*** .....

*Identity of **L*** .....

*Identity of **M*** .....

*Identities of **N** and **Q*** .....

.....

(6 marks)

8

Turn over for the next question

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4 The following equation represents a reaction in equilibrium.

$$\mathbf{X}(g) + 2\mathbf{Y}(g) \rightleftharpoons 2\mathbf{Z}(g)$$

(a) Explain what is meant by a *reaction in equilibrium*.

.....

.....

(2 marks)

(b) State and explain the effect on the yield of **Z** if the overall pressure is increased.

Effect .....

Explanation .....

.....

.....

(3 marks)

(c) An increase in temperature causes a decrease in the yield of **Z**. State and explain what can be deduced about the enthalpy change for the forward reaction.

Enthalpy change .....

Explanation .....

.....

(2 marks)

7

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5 (a) State two reasons why aluminium is a commonly used metal.

Reason 1 .....

Reason 2 .....

(2 marks)

(b) (i) Aluminium is extracted from its oxide by electrolysis. State the conditions used and give a half-equation for the reaction occurring at each electrode.

Conditions .....

.....

Half-equation 1 .....

Half-equation 2 .....

(ii) State the type of reaction occurring at the negative electrode.

.....

(5 marks)

(c) The thermite reaction is a batch process in which powdered aluminium reacts with iron(III) oxide. The products are aluminium oxide and iron. Write an equation for this reaction and state the role of aluminium.

Equation .....

Role of aluminium .....

(2 marks)

(d) Industrially, iron is obtained from iron(III) oxide in the Blast Furnace. Write an equation and state the necessary condition for the formation of iron from iron(III) oxide in the Blast Furnace.

Equation .....

Condition .....

(2 marks)

(e) Give **two** reasons why it is cheaper to produce iron in the Blast Furnace than in the thermite process.

Reason 1 .....

Reason 2 .....

(2 marks)

13

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SECTION B

Answer the question in the space provided.

6 (a) Draw a graph to show a Maxwell–Boltzmann distribution of molecular energies for a gas. Label the axes. On the same axes draw a second curve to show the distribution for the gas at a higher temperature. Label this second curve **W**.

(6 marks)

(b) A reaction of nitrogen monoxide is shown below.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

The rate of reaction can be found by measuring the concentration of NO_2 at different times.
Define the term *rate of reaction*. Draw a graph to show how the concentration of NO_2 changes with time. Indicate how the initial rate of reaction could be obtained from your graph.

(4 marks)

(c) In the manufacture of sulphur trioxide from sulphur dioxide, nitrogen monoxide can be used in a two-stage process to increase the rate of production.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

$$NO_2(g) + SO_2(g) \longrightarrow NO(g) + SO_3(g)$$

Construct an overall equation for the production of SO_3 from SO_2
State and explain fully the role of NO in this process.

(5 marks)

END OF QUESTIONS

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