Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM2
Unit 2 Foundation Physical and Inorganic Chemistry

Wednesday 8 June 2005 Morning Session

In addition to this paper you will require:
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 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 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.
- Mark allocations are shown in brackets.
- This paper carries 30 per cent of the total marks for AS. For Advanced Level this paper carries 15 per cent of the total marks.
- You are expected to use a calculator where appropriate.
- The following data may be required.
  Gas constant $R = 8.31$ J K^{-1} mol^{-1}
- Your answers to the question in **Section B** should be written 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			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 (a) Explain the meaning of the terms *mean bond enthalpy* and *standard enthalpy of formation*.

Mean bond enthalpy .....

.....

.....

Standard enthalpy of formation .....

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.....

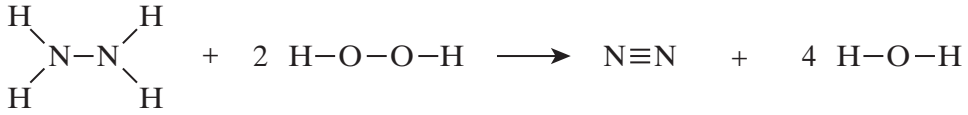
.....

(5 marks)

(b) Some mean bond enthalpies are given below.

Bond	N−H	N−N	N≡N	H−O	O−O
Mean bond enthalpy/kJ mol^{-1}	388	163	944	463	146

Use these data to calculate the enthalpy change for the following gas-phase reaction between hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2



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(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

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

(c) Some standard enthalpies of formation are given below.

	$N_2H_4(g)$	$H_2O_2(g)$	$H_2O(g)$
$\Delta H_f^{\ominus}$/kJ mol^{-1}	+75	−133	−242

These data can be used to calculate the enthalpy change for the reaction in part (b).

$$N_2H_4(g) + 2H_2O_2(g) \rightarrow N_2(g) + 4H_2O(g)$$

(i) State the value of $\Delta H_f^{\ominus}$ for $N_2(g)$.

.....

(ii) Use the $\Delta H_f^{\ominus}$ values from the table to calculate the enthalpy change for this reaction.

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.....

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(4 marks)

(d) Explain why the value obtained in part (b) is different from that obtained in part (c)(ii).

.....

.....

(1 mark)

13

TURN OVER FOR THE NEXT QUESTION

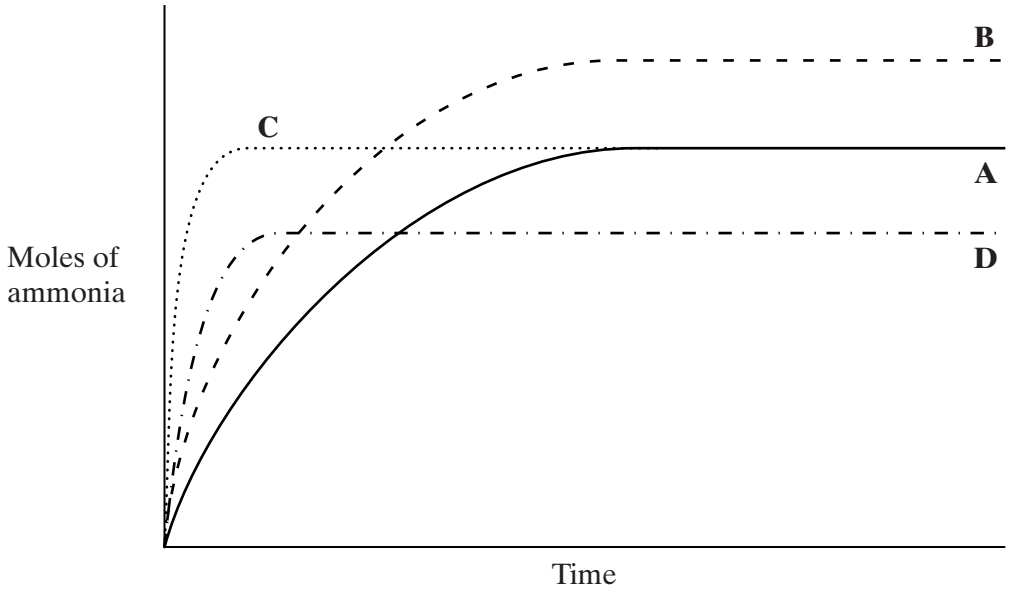
2 The equation for the formation of ammonia is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Experiment **A** was carried out starting with 1 mol of nitrogen and 3 mol of hydrogen at a constant temperature and a pressure of 20 MPa.

Curve **A** shows how the number of moles of ammonia present changed with time.

Curves **B**, **C** and **D** refer to similar experiments, starting with 1 mol of nitrogen and 3 mol of hydrogen. In each experiment different conditions were used.



(a) On curve **A**, mark the point that represents the time at which equilibrium is first reached. Label this point **X**.

(1 mark)

(b) State Le Chatelier's principle.

.....

.....

(1 mark)

(c) Use Le Chatelier's principle to identify which one of the curves **B**, **C** or **D** represents an experiment carried out at the same temperature as experiment **A** but at a higher pressure. Explain why this curve is different from curve **A**.

Curve .....

Explanation .....

.....

.....

.....

(4 marks)

(d) Identify which one of the curves **B**, **C** or **D** represents an experiment in which the conditions are the same as in experiment **A** except that a catalyst is added to the reaction mixture. Explain your choice of curve.

Curve .....

Explanation .....

.....

.....

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

3 (a) State and explain the trend in electronegativity down Group VII from fluorine to iodine.

Trend .....

Explanation .....

.....

.....

(3 marks)

(b) State what you would observe when chlorine gas is bubbled into an aqueous solution of potassium iodide. Write an equation for the reaction that occurs.

Observation .....

Equation .....

(2 marks)

(c) Identify **two** sulphur-containing reduction products formed when concentrated sulphuric acid oxidises iodide ions. For each reduction product, write a half-equation to illustrate its formation from sulphuric acid.

Reduction product 1 .....

Half-equation .....

Reduction product 2 .....

Half-equation .....

(4 marks)

(d) Write an equation for the reaction between chlorine gas and dilute aqueous sodium hydroxide. Name the **two** chlorine-containing products of this reaction and give the oxidation state of chlorine in each of these products.

Equation .....

Name of product 1 .....

Oxidation state of chlorine in product 1 .....

Name of product 2 .....

Oxidation state of chlorine in product 2 .....

(5 marks)

14

4 Reducing agents are used in the extraction of metals.

(a) In terms of electrons, state the function of a reducing agent.

.....

(1 mark)

(b) Identify a reducing agent used in the extraction of iron. Write an equation for the redox reaction in which iron is formed from iron(III) oxide using this reducing agent.

Reducing agent .....

Equation .....

(2 marks)

(c) Identify a reducing agent used to obtain titanium metal from titanium(IV) chloride. In addition to a high temperature, state a condition that is used for this reaction and explain why this condition is necessary.

Reducing agent .....

Condition .....

Explanation .....

.....

(3 marks)

(d) (i) State **two** essential conditions used for the electrolytic extraction of aluminium from aluminium oxide.

Condition 1 .....

Condition 2 .....

(ii) Write an equation to illustrate how aluminium is formed from aluminium ions in this process.

.....

(3 marks)

9

SECTION B

Answer the question below in the space provided on pages 10 to 12 of this booklet.

5 (a) Define the term *activation energy* for a chemical reaction. *(2 marks)*

(b) Draw, with labelled axes, a curve to represent the Maxwell–Boltzmann distribution of molecular energies in a gas. Label this curve $\mathbf{T_1}$. On the same axes, draw a second curve to represent the same sample of gas at a lower temperature. Label this curve $\mathbf{T_2}$.

Use these curves to explain why a small decrease in temperature can lead to a large decrease in the rate of a reaction. *(8 marks)*

(c) Give **one** reason why most collisions between gas-phase reactants do not lead to a reaction. State and explain **two** ways of speeding up a gas-phase reaction other than by changing the temperature. *(5 marks)*

END OF QUESTIONS

LEAVE MARGIN BLANK