

Name:

School:



DULWICH COLLEGE

UPPER SCHOOL

CHEMISTRY ENTRANCE TEST

2009 – 2010

75 minutes

Instructions

- Answer all the questions in the spaces provided. Remember to put your name and school at the top of this page.
- Use black ink (but pencil for any graphs). A calculator may be required.
- A Periodic Table (containing all the required relative atomic masses etc.) is provided at the back of this test. You may detach it if you wish.
- Show **all** of your working in any calculations.
- The number of marks for each question is indicated at the end of that question.

FOR MARKER'S USE ONLY

Comments:	Mark / 75



1. (a) The electronic configuration of a magnesium atom can be represented as:

2, 8, 2

Give the electronic configuration of a calcium atom.

..... [1]

(b) If calcium metal is heated strongly in a stream of nitrogen gas, the compound calcium nitride is formed.

(i) Draw a dot-and-cross diagram to show the bonding in calcium nitride. *Only the outer shell electrons need to be shown.*

[4]

(ii) Give a fully balanced symbol equation to represent this reaction.

..... [2]

(iii) Molten calcium nitride conducts electricity. However, solid calcium nitride does not. Explain this observation.

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..... [3]

(c) Calcium metal reacts readily with cold water. However, magnesium metal (also in Group 2) only reacts with water in the form of steam.

By comparing their electronic structures, explain why magnesium is less reactive than calcium.

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..... [3]

13 marks



2. In a series of experiments to investigate the factors which control the rate of a chemical reaction, aqueous hydrochloric acid was added to calcium carbonate in a conical flask placed on an electronic balance. The following reaction took place:



The loss in mass of the flask and its contents was recorded for 15 minutes.

Four experiments were carried out:

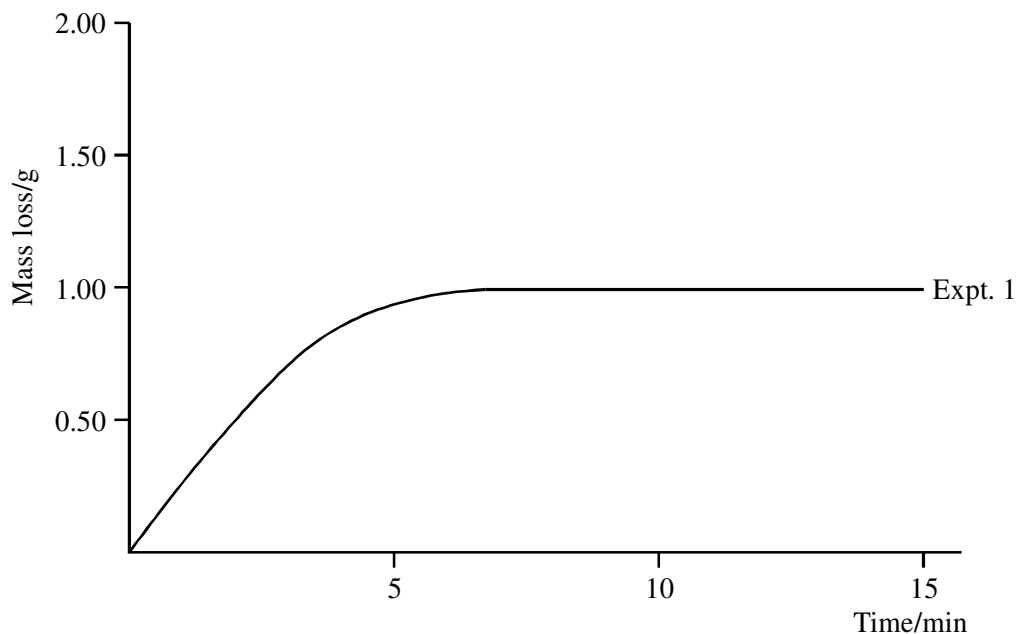
Experiments **1, 3** and **4** were carried out at room temperature (20 °C).

The same mass of calcium carbonate (a large excess) was used in each experiment.

The pieces of calcium carbonate were the same size in experiments **1, 2** and **4**.

Experiment	Calcium carbonate	Hydrochloric acid
1	Small pieces	50.0 cm ³ of 1.00 mol dm ⁻³
2	Small pieces	50.0 cm ³ of 1.00 mol dm ⁻³ heated to 80°C
3	One large piece	50.0 cm ³ of 1.00 mol dm ⁻³
4	Small pieces	50.0 cm ³ of 2.00 mol dm ⁻³

(a) The results of experiment **1** give the curve shown on the graph below.



(i) Explain why there is a loss in mass as the reaction proceeds.

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..... [2]

(ii) Explain the shape of the curve drawn for experiment **1**.

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..... [2]



(b) Draw **curves on the graph** to represent the results you would expect for experiments **2, 3** and **4**.
Label the curves **2, 3** and **4**. [3]

(c) (i) Calculate the mass of calcium carbonate which **exactly** reacts with 50.0 cm³ of 1.00 mol dm⁻³ aqueous hydrochloric acid. $M_r(\text{CaCO}_3) = 100$.

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..... [3]

(ii) Based on your answer to (c)(i) suggest a suitable mass of calcium carbonate to use in the experiments. Explain your answer.

Suggested mass:

Explanation:

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..... [2]

(d) In a different experiment, the same mass of calcium carbonate, and the same volume of hydrochloric acid are mixed. However, the acid is twice as concentrated. Explain what happens to the reaction rate.

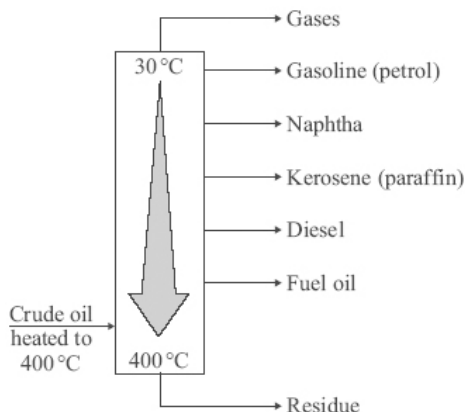
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..... [3]

(e) If the temperature of the acid is increased, the rate of reaction increases. Use collision theory to explain why this happens.

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..... [3]



3. Crude oil is the source of many useful materials. Crude oil is separated into fractions by fractional distillation.

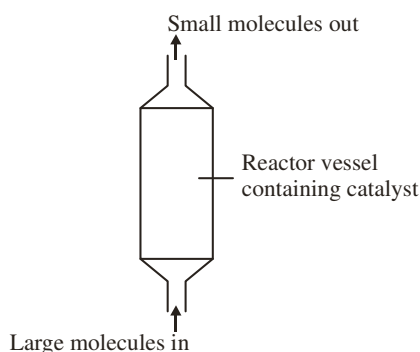


(a) Describe how the naphtha fraction separates from the other fractions.

.....

 [2]

(b) The naphtha fraction is often used to make other useful materials. This involves the **cracking** of hydrocarbons in the naphtha fraction.



(i) Cracking involves a thermal decomposition reaction.

Define the term **thermal decomposition**.

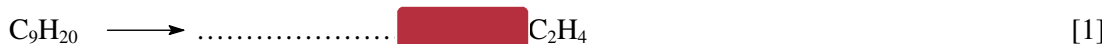
.....
 [2]

(ii) Suggest why air must be excluded from the reactor vessel.

.....
 [1]

(iii) In the reactor vessel, a nonane (C_9H_{20}) molecule is split into two smaller molecules.

Complete the equation for this reaction by adding the missing formula.



(iv) The product with the formula C_2H_4 is called ethene. Draw a line diagram to show the bonding in ethene.

[1]

(v) Bromine water can be used to distinguish between the two products from the cracking reaction in (c) (i) above.

Describe what you would see when each molecule is shaken (separately) with bromine water.

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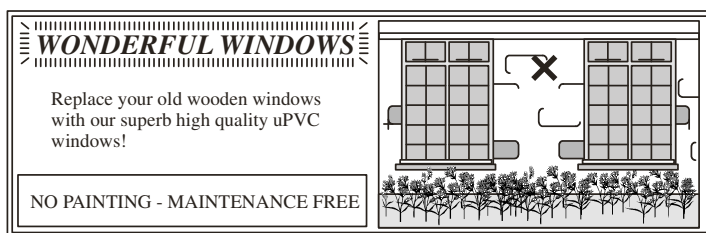
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..... [3]

(d) Small molecules such as ethene can be joined together to make long-chained polymers.



Modern window frames are often made from uPVC plastic which contains the *polymer* called poly(chloroethene).

(i) State why plastic window frames need no painting or maintenance.

.....

..... [1]

(ii) Name the monomer that is used to make poly(chloroethene).

..... [1]

(iii) Draw a line diagram to show the repeating unit in poly(chloroethene).

[1]

(iv) Describe **one** environmental hazard with plastics such as poly(chloroethene).

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..... [2]



4. When phosphorus is heated in bromine vapour, molecules of phosphorus bromide are produced. There are two possible bromides that can form – depending on the proportions of phosphorus and bromine in the reacting mixture.

If excess bromine is used, the molecule formed contains 7.19% phosphorus and 92.81% bromine (by mass).

(a) (i) What is the empirical formula of this compound?

[4]

(ii) Write a balanced symbol equation for this reaction.

..... [2]

(b) Under different conditions, phosphorus tribromide (PBr_3) can be produced.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of phosphorus tribromide. *Only the outer shell electrons need to be shown.*

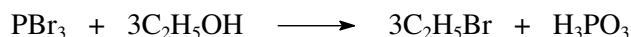
[2]

(ii) Phosphorus tribromide has melting point of $-41.5\text{ }^\circ\text{C}$. By describing its structure and bonding, explain why its melting point is relatively low.

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..... [3]



- (iii) The most important reaction of phosphorus tribromide is with alcohols (such as ethanol) where it replaces an OH group with a bromine atom to produce an alkyl bromide. (These compounds are very useful for synthesising other organic molecules.)



What mass of phosphorus tribromide is needed to make 90 tonnes of bromoethane ($\text{C}_2\text{H}_5\text{Br}$)? Give your answer (in tonnes) to 3 significant figures. [1 tonne = 1000 kg]

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..... [3]

- (iv) In practice, the mass of phosphorus tribromide calculated above only generates 67 tonnes of bromoethane. What percentage yield is this?

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..... [1]

15 marks

5. Aluminium metal is manufactured by a process in which purified bauxite, dissolved in molten cryolite, is electrolysed at 800 °C. Graphite electrodes and a current of about 120 000 amperes are used.

- (a) (i) Give the **ionic equations** for the reactions taking place at each electrode.

Anode: [1]

Cathode: [1]

- (ii) State which of these reactions is an oxidation process.

..... [1]

- (iii) Explain why the anodes need to be replaced frequently.

.....
..... [2]



(b) The production of aluminium is expensive.

(i) Explain why, despite this high cost, aluminium is manufactured in large quantities.

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..... [2]

(ii) Give **two reasons** why it is worthwhile to recycle aluminium.

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..... [2]

(c) Aluminium is relatively high in the reactivity series and yet it tends to react much more slowly than expected. Why is this?

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..... [1]

10 marks

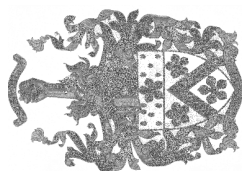
TOTAL: 75 MARKS

THIS IS THE END OF THE QUESTIONS

NOW GO BACK AND CHECK YOUR ANSWERS



THE PERIODIC TABLE



Period **1** **2** **3** **4** **5** **6** **7** **0**

Group

Key

1	H Hydrogen 1
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Atomic Number
Symbol
Name
Molar mass in g mol ⁻¹

2	He Helium 4
---	--------------------------

3	Li Lithium 7	4	Be Beryllium 9
11	Na Sodium 23	12	Mg Magnesium 24
19	K Potassium 39	20	Ca Calcium 40
37	Rb Rubidium 85	38	Sr Strontium 88
55	Cs Caesium 133	56	Ba Barium 137
87	Fr Francium (223)	88	Ra Radium (226)

21	Sc Scandium 45	22	Ti Titanium 48	23	V Vanadium 51	24	Cr Chromium 52	25	Mn Manganese 55	26	Fe Iron 56	27	Co Cobalt 59	28	Ni Nickel 59	29	Cu Copper 63.5	30	Zn Zinc 65.4	
39	Y Yttrium 89	40	Zr Zirconium 91	41	Nb Niobium 93	42	Mo Molybdenum 96	43	Tc Technetium (99)	44	Ru Ruthenium 101	45	Rh Rhodium 103	46	Pd Palladium 106	47	Ag Silver 108	48	Cd Cadmium 112	
57	La Lanthanum 139	72	Hf Hafnium 178	73	Ta Tantalum 181	74	W Tungsten 184	75	Re Rhenium 186	76	Os Osmium 190	77	Ir Iridium 192	78	Pt Platinum 195	79	Au Gold 197	80	Hg Mercury 201	
89	Ac Actinium (227)	104	Unq Unnilquadium (261)	105	Unp Unnilpentium (262)	106	Unh Unnilhexium (263)													

31	Ga Gallium 70	32	Ge Germanium 73	33	As Arsenic 75	34	Se Selenium 79	35	Br Bromine 80	36	Kr Krypton 84
49	In Indium 115	50	Sn Tin 119	51	Sb Antimony 122	52	Te Tellurium 128	53	I Iodine 127	54	Xe Xenon 131
81	Tl Thallium 204	82	Pb Lead 207	83	Bi Bismuth 209	84	Po Polonium (210)	85	At Astatine (210)	86	Rn Radon (222)

► **Lanthanide elements**
►► **Actinide elements**

58	Ce Cerium 140	59	Pr Praseodymium 141	60	Nd Neodymium 144	61	Pm Promethium (147)	62	Sm Samarium 150	63	Eu Europium 152	64	Gd Gadolinium 157	65	Tb Terbium 159	66	Dy Dysprosium 163	67	Ho Holmium 165	68	Er Erbium 167	69	Tm Thulium 169	70	Yb Ytterbium 173	71	Lu Lutetium 175
90	Th Thorium 232	91	Pa Protactinium (231)	92	U Uranium 238	93	Np Neptunium (237)	94	Pu Plutonium (242)	95	Am Americium (243)	96	Cm Curium (247)	97	Bk Berkelium (245)	98	Cf Californium (251)	99	Es Einsteinium (254)	100	Fm Fermium (253)	101	Md Mendelevium (256)	102	No Nobelium (254)	103	Lr Lawrencium (257)

