St Mary's School
CAMBRIDGE

Lower Sixth Chemistry

Sample Entrance Examination

Time allowed: 60 minutes

Name: _____

Total : 60 Marks

INSTRUCTIONS :

- **Answer all questions**
- **Answers should be written in the spaces provided**
- **Dictionaries or reference materials are forbidden**

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

Key

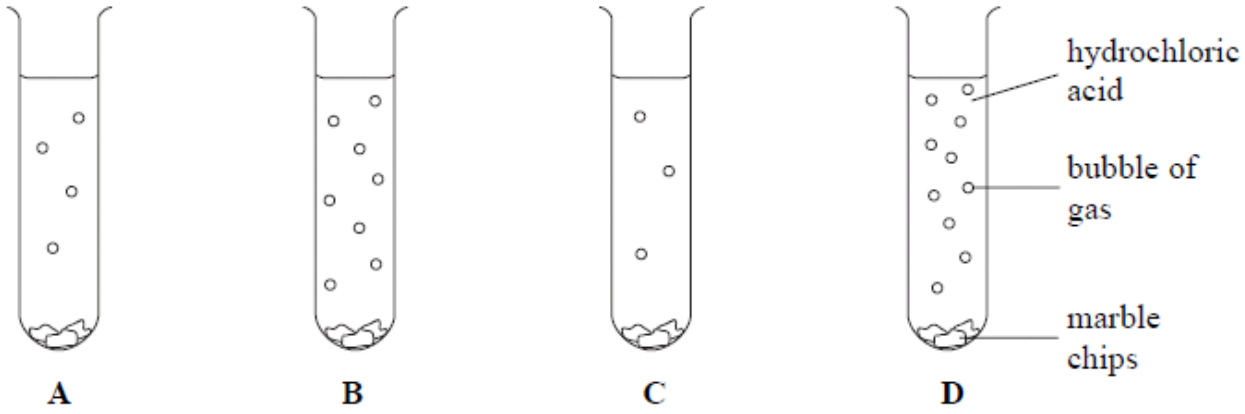
relative atomic mass
atomic symbol
name
atomic (proton) number

**** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.

Use this information to answer Questions 1, 2 and 3

Emily added the same sized marble chips to different concentrations of hydrochloric acid in four test tubes.



1. Which of these would **not** speed up the reaction?

A warming the tubes
B adding more concentrated acid
C using the same mass of smaller marble chips
D adding water to the tubes

Answer: .....**[1]**

2. Emily wonders if she could add a catalyst to the reaction.
Which row of the table below describes a catalyst and its effect?

	mass of catalyst after reaction	**changes the rate of reaction**
A	has decreased	no
B	has stayed the same	yes
C	has stayed the same	no
D	has decreased	yes

Answer: .....**[1]**

3. Explain which tube contained the most concentrated acid.

.....

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

Ammonia is made by the Haber process.
The equation is

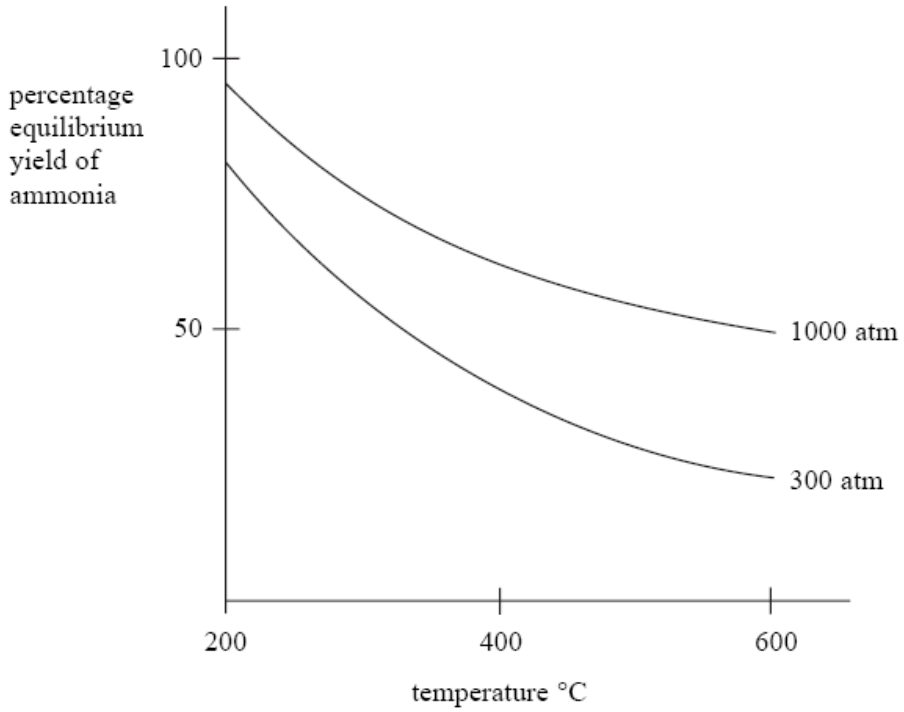
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

4. If the process reaches equilibrium, which of these statements is correct?

A only ammonia is present
B reactions continue to take place
C only nitrogen and hydrogen are present
D the reverse reaction starts

Answer: .....**[1]**

5. The graph shows how the equilibrium yield of ammonia changes with temperature and different pressures.



Use the graph to decide which of these conditions would produce the highest percentage equilibrium yield of ammonia?

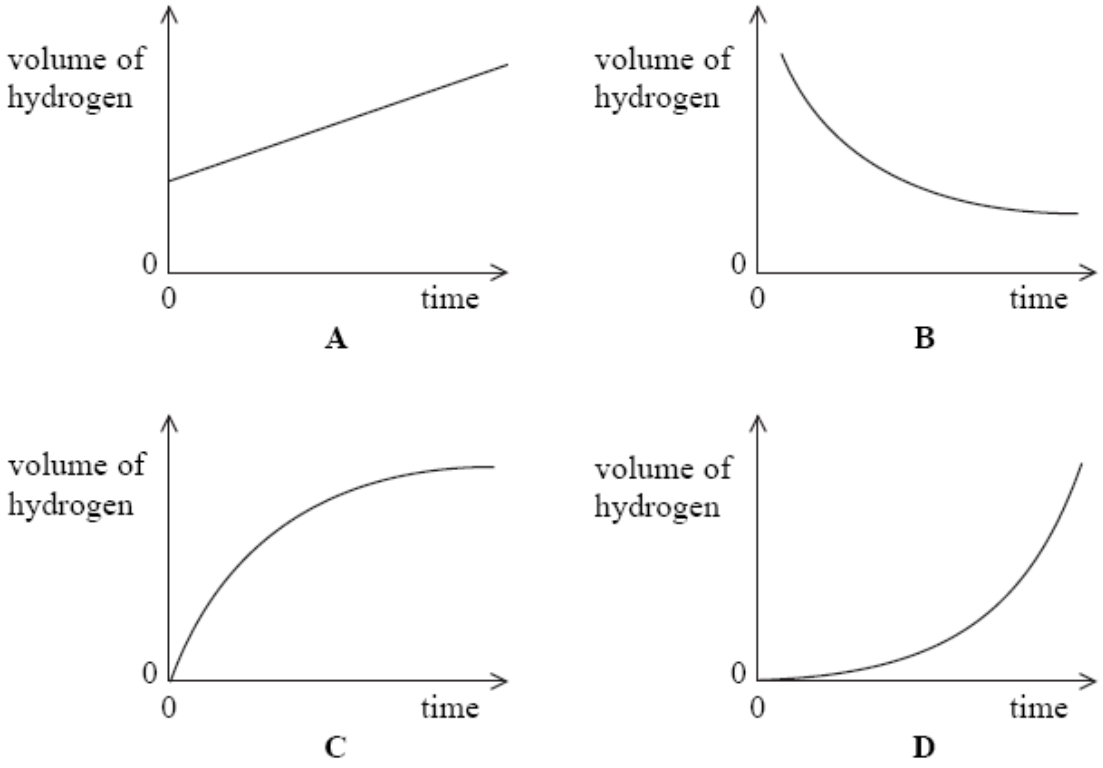
A 200°C and 1000 atmospheres
B 600°C and 300 atmospheres
C 200°C and 300 atmospheres
D 400°C and 1000 atmospheres

Answer: .....**[1]**

Use the following information to answer questions 6 and 7.

Magnesium sulfate is formed when magnesium reacts with dilute sulfuric acid.
Jane investigated the rate of this reaction by adding magnesium to excess dilute sulfuric acid (25 cm^3)
Every 30 seconds she recorded the total volume of hydrogen produced until the reaction was complete. She plotted a graph of her results.

6. Which is the correct graph?



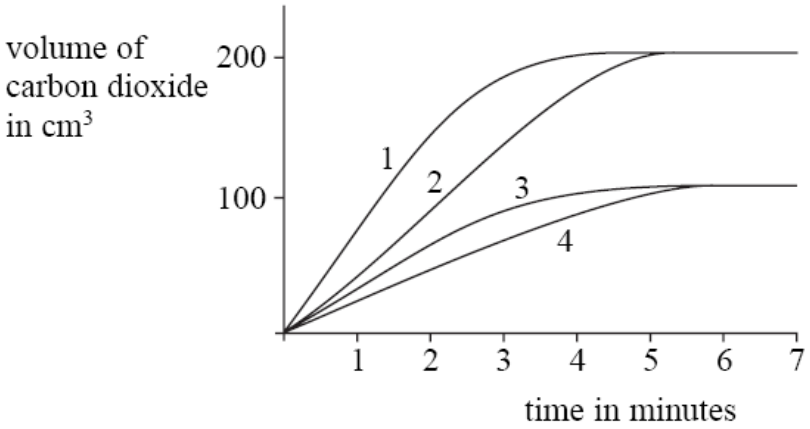
Answer: .....**[1]**

7. She repeated the experiment using the same mass of magnesium but 50cm^3 of the same acid. She found that

A the final volume of hydrogen was larger
B the rate of reaction was the same
C it took longer to produce the same volume of hydrogen
D the rate of reaction was greater

Answer: .....**[1]**

In four separate experiments, 1, 2, 3, and 4, nitric acid was added to excess marble chips and the volume of carbon dioxide formed was measured.
In all the experiments the same volume of acid was used each time but its concentration and/or temperature were changed.
The results of the experiments are shown on the graphs.



8. Which of these statements is correct?

A the temperature of the acid was the same in experiments 1 and 2.
B the acid used in experiment 2 was at a higher temperature than in experiment 1
C experiment 4 was faster than experiment 3
D a lower concentration of acid was used in experiment 3 than in experiment 1

Answer: .....**[1]**

9. The reaction can be speeded up by increasing the surface area of the marble chips.
If the surface area of the marble chips is increased and all other conditions remain the same, the particle collisions are

A more frequent and of the same energy
B more frequent and of higher energy
C of the same frequency and of the same energy
D of the same frequency and of higher energy

Answer: .....**[1]**

10. Hydrogen peroxide, H_2O_2, decomposes to form water and oxygen gas.

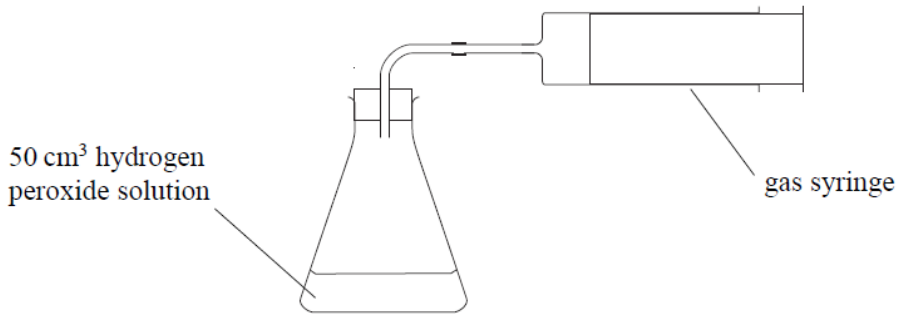
(a) (i) Write the balanced equation for this reaction.

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

(ii) Plan an experiment to find the effect of temperature on the rate of decomposition of a given hydrogen peroxide solution.

Use 50 cm^3 samples of the hydrogen peroxide solution in the apparatus shown and describe what you would do and what readings you would take.

[note: you are not expected to have carried out this experiment before, the question is testing your ability to plan experiments to collect reliable and valid results]



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.....**[3]**

(b) Emma investigated a reaction between a solid and a liquid. The reaction produced a gas.
She wanted to know if any of the substances X, Y or Z were catalysts for the reaction.
She carried out the reaction without any X, Y or Z.
She then repeated the reaction three more times under exactly the same conditions but she added a small amount of X, Y or Z.
In each case she timed how long it took for the reaction to finish.

The results are shown in the table.

substance added	**time (s)**
none	167
X	156
Y	169
Z	8

State if each of X, Y and Z acted as a catalyst and give reasons for your answers.

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

11. Ethene gas (C_2H_4) reacts with steam at 300°C and 65 atm to form ethanol gas (C_2H_5OH).

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

The forward reaction is exothermic.

(a) How would the yield of ethanol at equilibrium change if the temperature was increased?
Explain you answer.

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

(b) A higher pressure would increase the yield of ethanol at equilibrium.
Suggest why a higher pressure is **not** used.

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.....**[1]**

(c) In terms of the bonds broken and formed during the reaction, explain why the forward reaction is exothermic.

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.....**[3]**

12. When hydrogen peroxide solution is added to a solution of iron(II) chloride, iron(III) chloride is formed. The hydrogen peroxide causes the following change to take place:

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^{-}$$

(a) Explain why this is described as an oxidation reaction.

.....**[1]**

(b) When sodium hydroxide solution is added to iron(III) chloride solution, iron(III) hydroxide is formed.

(i) Describe what would be seen in this reaction.

.....

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

(ii) Write the ionic equation for this reaction.

.....**[3]**

13. The industrial production of sodium carbonate is a complicated process involving many stages.

(a) The equation for the overall reaction is

$$CaCO_3(s) + 2NaCl(aq) \rightarrow Na_2CO_3(aq) + CaCl_2(s)$$

Calculate the minimum mass of calcium carbonate required to produce 1 million tonnes of sodium carbonate.

(Relative atomic masses: C = 12.0, O = 16.0, Na = 23.0, Ca = 40.0)

.....

.....

.....

.....**[4]**

answer = ... tonnes

(b) When the sodium carbonate solution crystallises, washing soda crystals are formed. These can be used to neutralise acids.
Write the balanced chemical equation for the reaction that takes place when sodium carbonate is used to neutralise sulphuric acid.

.....**[3]**

14. In an experiment to determine the solubility of calcium hydroxide in water Julia shook excess calcium hydroxide with water in a large, stoppered flask. She allowed the mixture to stand for 24 hours. She then filtered the mixture to remove excess solid.

Julia took 100 cm^3 of the solution for analysis.
She titrated 10.0 cm^3 portions of the solution with 0.0500 mol dm^{-3} hydrochloric acid, HCl, to determine how much calcium hydroxide had been dissolved.
She used methyl orange as the indicator.

Here are her results.

volume of calcium hydroxide solution used for each titration		=	10.0 cm^3
volume of hydrochloric acid added	trial titration	=	9.30 cm^3
	1st titration	=	8.90 cm^3
	2nd titration	=	8.80 cm^3
	Average	=	8.85 cm^3

(a) Why is universal indicator not suitable for this titration?

.....

..... **[1]**

(b) The equation for the reaction is

$$Ca(OH)_2\ (aq) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + 2H_2O\ (l)$$

Calculate the number of moles of calcium hydroxide, $Ca(OH)_2$, present in the **original** 100cm^3 of the solution

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..... **[3]**

answer = ...

Using information from the periodic table calculate the relative formula mass of calcium hydroxide?

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..... **[1]**

(d) Use your answer to (b) and your answer to (c) to calculate the mass of calcium hydroxide dissolved in the original 100cm^3 solution.

Note: if you have been unable to calculate an answer to (b) use the number 0.003 moles

if you have been unable to calculate an answer to (c) use the number 70.

.....

answer = ... g

[1]

15. Sodium and potassium are reactive metals in the same group of the periodic table.

(a) The sodium atom contains electrons, neutrons and protons.

(i) Describe the position of these particles in the sodium atom.

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

(ii) A sodium atom has an atomic number of 11 and a mass number of 23.
State the number of each type of particle in this sodium atom.

..... protons

..... electrons

..... neutrons

[2]

(b) When sodium is heated and put into a gas jar of oxygen, a reaction takes place.
The product is sodium oxide.
The sodium oxide contains sodium ions, Na^+, and oxide ions, O^{2-}.

(i) Write the formula of sodium oxide.

.....**[1]**

(ii) Sodium oxide has a high melting point. Explain why.

.....

.....**[1]**

(iii) Sodium oxide conducts electricity when it is molten. Explain why.

.....

.....**[1]**

(c) The electronic configuration of sodium is 2.8.1.
Potassium has 19 electrons.

(i) What is the electronic configuration of potassium?

.....**[1]**

(ii) Potassium is more reactive than sodium.
Use the electronic configurations of their atoms to explain why.

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

16. This question is about chlorine gas.
The electronic configuration of the chlorine atom is 2.8.7.

(a) Draw a dot and cross diagram to show a chlorine molecule (Cl_2).
Show only the outer shell electrons.

[2]

(b) There are two isotopes of chlorine.

isotope	mass number	abundance
chlorine-35 (^{35}Cl)	35	75%
chlorine-37 (^{37}Cl)	37	25%

(i) In terms of the structure of their atoms, describe the differences and similarities between these two isotopes.

.....

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

(ii) Use the information in the table to calculate the relative atomic mass of chlorine. Show your working.

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answer = ... **[1]**

(c) Chlorine reacts with sodium to form the ionic compound, sodium chloride, NaCl.

$$2\ Na\ (s) + Cl_2\ (g) \rightarrow 2\ NaCl\ (s)$$

(i) Explain how sodium and chlorine atoms react to form sodium and chloride ions.

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

(d) In an experiment 1.15g of sodium reacts with excess chlorine to produce 1.75g of sodium chloride. Calculate the percentage yield of sodium chloride in this experiment.

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..... **[3]**

End of Examination

[Total: 60 marks]