

TONBRIDGE SCHOOL

Specimen paper for entry into Year 12

Chemistry

Time allowed : 45 minutes

Total Marks : 30

Answer any **THREE** questions on the lined paper provided.

All questions are out of 10. Choose questions that you feel you will score most highly on. We recommend that you spend the first 5 minutes of the exam reading through all of the questions to help you to select the right questions to answer.

Answer any THREE questions

1. Nitrogen trichloride, NCl_3 , is an oily liquid which explodes spectacularly when heated or shaken. Its discoverer, Pierre Dulong, lost two fingers and an eye in the process. As a result of these dangers it has no common uses! It forms in small quantities from the reaction of chlorine in swimming pools with ammonia.

- (a) Write a balanced equation, including state symbols, for the detonation of nitrogen trichloride, giving nitrogen and chlorine as the only products [2]
- (b) Draw a dot and cross diagram to show the outer electrons of nitrogen trichloride [2]
- (c) Explain why you would expect nitrogen trichloride to boil easily [2]
- (d) Write a balanced equation for the reaction between chlorine and ammonia to produce nitrogen trichloride and ammonium chloride, NH_4Cl [2]
- (e) Using the covalent bond lengths given in the table below, suggest why nitrogen tribromide is even more hazardous than nitrogen trichloride [2]

Bond	Bond length / nm
N–Cl	0.176
N–Br	0.198

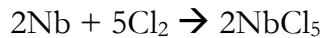
2. Air is a mixture of gases which can be separated by fractional distillation. To achieve this, air is compressed then allowed to expand repeatedly until it condenses. A heat exchange system is required at various stages.

- (a) State the approximate percentages of nitrogen, oxygen and carbon dioxide in dry air [2]
- (b) Suggest why the air contains almost no hydrogen and helium, despite them being by far the most abundant elements in the universe [2]
- (c) Describe briefly the change in the arrangement of the particles when air is compressed to become a liquid [2]
- (d) Describe briefly the changes in the motion of the particles when liquid air is boiled [2]
- (e) Suggest a stage where the heat exchange system is required and give a reason for its use [2]

3. Bromine is a magnificent element, whose name comes from the Greek for stench. It is extracted from seawater by oxidation with chlorine, an element extracted from sodium chloride solution by electrolysis. Extraction of bromine has four stages, the first of which sees chlorine bubbled through a solution of bromide ions and the third sees the reduction of damp bromine vapour by sulfur dioxide to give hydrogen bromide and sulfuric acid. Bromine is more reactive than iodine, with spectacular reactions including that with aluminium powder.

- (a) Write a balanced ionic equation for the oxidation of bromide ions by chlorine [2]
- (b) Explain why the process is known as the oxidation of bromide ions [1]
- (c) Write a balanced equation for the reduction of damp bromine by sulfur dioxide [2]
- (d) Suggest why bromine is more reactive than iodine [2]
- (e) Draw a dot and cross diagram to represent the bonding in aluminium bromide [2]
- (f) Suggest a balanced equation for the reaction of bromine and aluminium [1]

4. The pair of elements in the periodic table, niobium and tantalum, are transition metals. They have almost identical properties and so are difficult to separate. They are extracted from an ore known as coltan, a mineral controversially mined in the Democratic Republic of Congo. After separation of tantalum and niobium oxides, pure niobium metal is formed by reduction of Nb_2O_5 with aluminium. Niobium metal reacts with chlorine according to the following equation:



- (a) Write a balanced chemical equation for the reduction of Nb_2O_5 by aluminium [2]
- (b) Calculate the maximum mass of niobium chloride, NbCl_5 , that could be made from 10g of chlorine gas [3]
- (c) A meteorite sample containing niobium was found to be 94% ^{93}Nb and 6% ^{94}Nb .
- (i) State the subatomic particles that make up an atom of ^{93}Nb [2]
 - (ii) Calculate the Relative Atomic Mass of this sample of niobium, giving your answer to 2 decimal places [2]
 - (iii) Explain why you would expect the two isotopes to have the same chemical reactivity [1]
5. Bottles of camping gas will often refer to isobutane as an ingredient. This is an isomer of butane, C_4H_{10} , more commonly known as methylpropane. It has a lower boiling point than butane and hence acts as a more flammable component of the mixture. The density of isobutane is 2.51 g per dm^3 of the gas, at normal atmospheric pressure.
- (a) Draw the displayed formula of a molecule of butane [1]
 - (b) Explain briefly the meaning of the term isomer [2]
 - (c) Write a balanced equation for the complete combustion of butane [2]
 - (d) A balloon with a volume of 2500 cm^3 contains pure isobutane at normal atmospheric pressure.
 - (i) What mass of isobutane would be in the balloon? [1]
 - (ii) How many moles of hydrogen atoms will be contained in this mass? [2]
 - (e) Suggest why isobutane has a lower boiling point than butane [2]

END OF PAPER

THE PERIODIC TABLE

	1	2	3	4	5	6	7	0
Period	Group							
1								
2	Li Lithium 3	Be Beryllium 4						
3	Na Sodium 11	Mg Magnesium 12						
4	K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26
5	Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Tc Tantalum 42	Ru Ruthenium 43	Rh Rhodium 44
6	Cs Caesium 55	Ba Barium 56	La Lanthanum 57	Hf Hafnium 72	Ta Tantalum 73	W Tungsten 74	Re Rhenium 75	Os Osmium 76
7	Fr Francium 87	Ra Radium 88	Ac Actinium 89					

Key

Relative atomic mass
Symbol
Name
Atomic number

1	H
2	He Helium

3	4	5	6	7	0	4	He Helium	2
11	12	14	16	19	20			
B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9	Ne Neon 10			
27	28	31	32	35.5	40			
Al Aluminium 13	Si Silicon 14	P Phosphorus 15	S Sulfur 16	Cl Chlorine 17	Ar Argon 18			
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