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 <u>arrangement</u> of the particles when air is compressed to become a liquid [2]
   (d) Describe briefly the changes in the <u>motion</u> 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:

$$2Nb + 5Cl_2 \rightarrow 2NbCl_5$$

(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 that 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

Period	Group 1	2										3	4	5	6	7	0
1	1 H Hydrogen 1																4 He Helium 2
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
3	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
4	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
5	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

Relative atomic mass
Symbol
Name
Atomic number