RADLEY

2020 Scholarship Examination Paper

CHEMISTRY

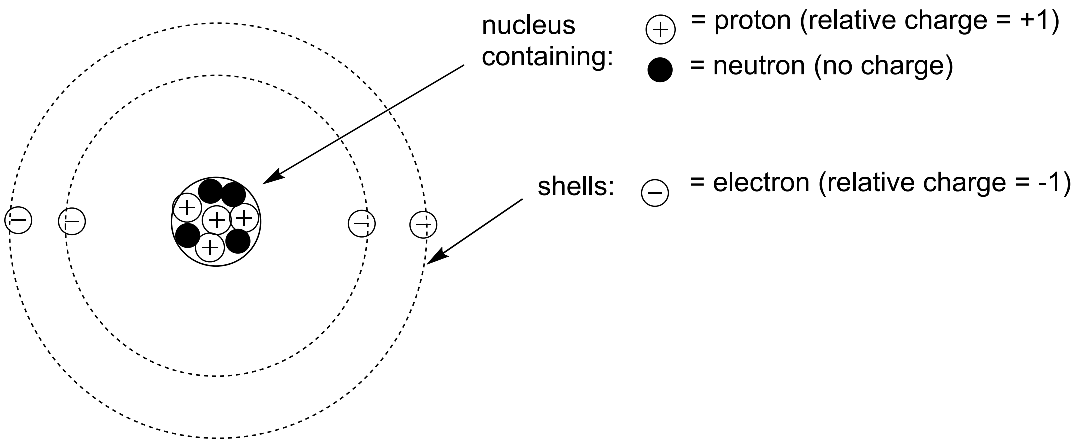
26 February – 27 February 2020

Time allowed – 30 minutes

Read the text carefully (you may wish to annotate or highlight certain sections) and then solve the questions relating to it.

The building blocks of matter around us are a type of particle called the atom. Atoms are very small and are themselves composed of a number of so-called subatomic particles. Different types of atoms (elements) are distinguished by having different numbers of subatomic particles.

The three subatomic particles are: protons, neutrons and electrons which, according to a simple model, are arranged as shown in the diagram below.



The Periodic Table contains all known elements arranged in order of increasing atomic number, that means of increasing number of protons. You can see a Periodic Table is at the end of this paper. Have a look at it and read on. The table is divided into **Groups** (the columns) and **Periods** (the rows). Both are labelled in the periodic table. So for example you will find the element boron in period 2 and group 13. It is an important feature of the Periodic Table that elements listed in the same group have similar chemical properties. So for example chlorine forms similar compounds as bromine.

As you can see in the diagram above, the protons and neutrons reside in the middle of the atom and form a nucleus around which the electrons are arranged in a shell structure. Each of the shells can accommodate a certain number of electrons. The number of shells present in an atom is given by the Period. The Group number is also useful to know as it will tell you the number of electrons in the outermost shell. Each element in the Periodic Table comes with two numbers in its box. The top one is called the atomic number, Z, and tells you how many protons an element has. The bottom number is called the average relative atomic mass number, M, and allows you to deduce you how many protons and neutrons an atom has. We usually round this number to the nearest whole number in order to calculate the neutron number, N.

Questions:

1. Answer the following questions about subatomic particles using the boxes on the right.

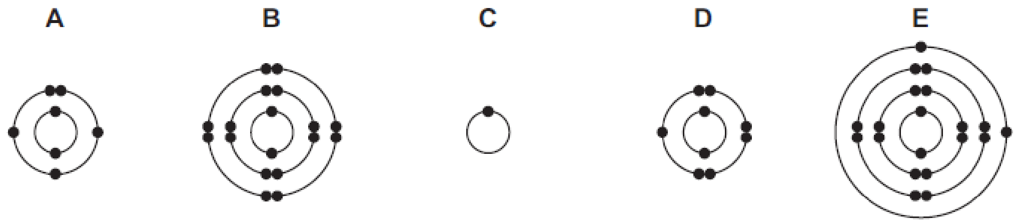
a) How many protons are there in an atom of sodium (symbol Na)?

b) How many electrons are there in the outer shell of an atom of fluorine (symbol F)?

c) Given the fact that atoms are neutral, how many electrons in total are there in an atom of carbon (symbol C)?

[3]

2. The electronic structure of five atoms of different elements, **A**, **B**, **C**, **D** and **E** are shown below.



Answer the following questions about these structures. Each structure may be used once, more than once or not at all.

Which diagram corresponds to an atom that

a) is in Period 4 of the Periodic Table?

b) is in Group 2 of the Periodic Table?

c) has five electrons in its outer shell?

d) has an atomic number of 7?

e) represents a fluorine atom?

[5]

3. a) State the chemical symbol for rubidium. ………………… [1]

b) Which element forms similar compounds to rubidium? *Circle the correct answer.*

strontium - lithium - krypton - beryllium

[1]

4. The mass of an atom is determined by the mass number. Which subatomic particle does not seem to be included in the mass? Why do you think this may be?

……

…… [2]

5. State the number of shells for the following elements.

Helium ………………… Boron ………………… Arsenic …………………

[3]

Neodymium magnets are probably the strongest commercially available magnets.

A small disc of diameter 10 mm and thickness 5 mm can hold up to 20 kg of mass.
The magnet consists of neodymium, iron and boron and has the formula, $Nd_2Fe_{14}B$. We call this formula the empirical formula. The empirical formula tells you the smallest whole number ratio of atoms in a compound. The small digits after each element symbol tell you how many atoms there are in one unit of the compound.

6. Reread the text above and try to find a way to calculate the number of neutrons in an atom from its atomic number and the atomic mass number. Can you write a general equation below?

…… [1]

7. Look up the place of neodymium in your Periodic Table (atomic number 60) and calculate the number of neutrons of an atom of neodymium by appropriately rounding the atomic mass number.

…… [1]

8. a) The real mass of one proton or neutron is 1.67×10^{-24} g (they have almost the same mass). What would be the real mass, in grams, of an atom of neodymium?

……

…… [2]

b) How many neodymium atoms would you need to obtain one gram of neodynium?

……

…… [1]

9. a) Determine the total number of atoms in one unit of $Nd_2Fe_{14}B$.

…… [1]

b) Using the relative masses of each of the atoms, what would be the relative mass of $Nd_2Fe_{14}B$? Round the relative atomics masses appropriately.

……

…… [2]

c) What would be the real mass, in kilograms, of $Nd_2Fe_{14}B$?

……

…… [2]

[Total: 25]

The Periodic Table of the Elements

Element name → Mercury
80 ← Atomic number
Symbol → **Hg**
200.59 ← Atomic Mass

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 **H** 1.01																		Helium 2 **He** 4.00
Lithium 3 **Li** 6.94	Beryllium 4 **Be** 9.01												Boron 5 **B** 10.81	Carbon 6 **C** 12.01	Nitrogen 7 **N** 14.01	Oxygen 8 **O** 16.00	Fluorine 9 **F** 19.00	Neon 10 **Ne** 20.18
Sodium 11 **Na** 22.99	Magnesium 12 **Mg** 24.31												Aluminum 13 **Al** 26.98	Silicon 14 **Si** 28.09	Phosphorus 15 **P** 30.97	Sulfur 16 **S** 32.07	Chlorine 17 **Cl** 35.45	Argon 18 **Ar** 39.95
Potassium 19 **K** 39.10	Calcium 20 **Ca** 40.08		Scandium 21 **Sc** 44.96	Titanium 22 **Ti** 47.88	Vanadium 23 **V** 50.94	Chromium 24 **Cr** 52.00	Manganese 25 **Mn** 54.94	Iron 26 **Fe** 55.85	Cobalt 27 **Co** 58.93	Nickel 28 **Ni** 58.69	Copper 29 **Cu** 63.55	Zinc 30 **Zn** 65.39	Gallium 31 **Ga** 69.72	Germanium 32 **Ge** 72.61	Arsenic 33 **As** 74.92	Selenium 34 **Se** 78.96	Bromine 35 **Br** 79.90	Krypton 36 **Kr** 83.80
Rubidium 37 **Rb** 85.47	Strontium 38 **Sr** 87.62		Yttrium 39 **Y** 88.91	Zirconium 40 **Zr** 91.22	Niobium 41 **Nb** 92.91	Molybdenum 42 **Mo** 95.94	Technetium 43 **Tc** (98)	Ruthenium 44 **Ru** 101.07	Rhodium 45 **Rh** 102.91	Palladium 46 **Pd** 106.42	Silver 47 **Ag** 107.87	Cadmium 48 **Cd** 112.41	Indium 49 **In** 114.82	Tin 50 **Sn** 118.71	Antimony 51 **Sb** 121.76	Tellurium 52 **Te** 127.60	Iodine 53 **I** 126.90	Xenon 54 **Xe** 131.29
Cesium 55 **Cs** 132.91	Barium 56 **Ba** 137.33	**57-70** *	Lutetium 71 **Lu** 174.97	Hafnium 72 **Hf** 178.49	Tantalum 73 **Ta** 180.95	Tungsten 74 **W** 183.84	Rhenium 75 **Re** 186.21	Osmium 76 **Os** 190.23	Iridium 77 **Ir** 192.22	Platinum 78 **Pt** 195.08	Gold 79 **Au** 196.97	Mercury 80 **Hg** 200.59	Thallium 81 **Tl** 204.38	Lead 82 **Pb** 207.20	Bismuth 83 **Bi** 208.98	Polonium 84 **Po** (209)	Astatine 85 **At** (210)	Radon 86 **Rn** (222)
Francium 87 **Fr** (223)	Radium 88 **Ra** (226)	**89-102** **	Lawrencium 103 **Lr** (262)	Rutherfordium 104 **Rf** (267)	Dubnium 105 **Db** (268)	Seaborgium 106 **Sg** (271)	Bohrium 107 **Bh** (272)	Hassium 108 **Hs** (270)	Meitnerium 109 **Mt** (276)	Darmstadtium 110 **Ds** (281)	Roentgenium 111 **Rg** (280)	Copernicium 112 **Cn** (285)	Ununtrium 113 **Uut** (284)	Ununquadium 114 **Uuq** (289)	Ununpentium 115 **Uup** (288)	Ununhexium 116 **Uuh** (293)	Ununseptium 117 **Uus** (294?)	Ununoctium 118 **Uuo** (294)

*lanthanides	Lanthanum 57 **La** 138.91	Cerium 58 **Ce** 140.12	Praseodymium 59 **Pr** 140.91	Neodymium 60 **Nd** 144.24	Promethium 61 **Pm** (145)	Samarium 62 **Sm** 150.36	Europium 63 **Eu** 151.97	Gadolinium 64 **Gd** 157.25	Terbium 65 **Tb** 158.93	Dysprosium 66 **Dy** 162.50	Holmium 67 **Ho** 164.93	Erbium 68 **Er** 167.26	Thulium 69 **Tm** 168.93	Ytterbium 70 **Yb** 173.04
**actinides	Actinium 89 **Ac** (227)	Thorium 90 **Th** 232.04	Protactinium 91 **Pa** 231.04	Uranium 92 **U** 238.03	Neptunium 93 **Np** (237)	Plutonium 94 **Pu** (244)	Americium 95 **Am** (243)	Curium 96 **Cm** (247)	Berkelium 97 **Bk** (247)	Californium 98 **Cf** (251)	Einsteinium 99 **Es** (252)	Fermium 100 **Fm** (257)	Mendelevium 101 **Md** (258)	Nobelium 102 **No** (259)