RADLEY

2020 Scholarship Examination Paper

CHEMISTRY

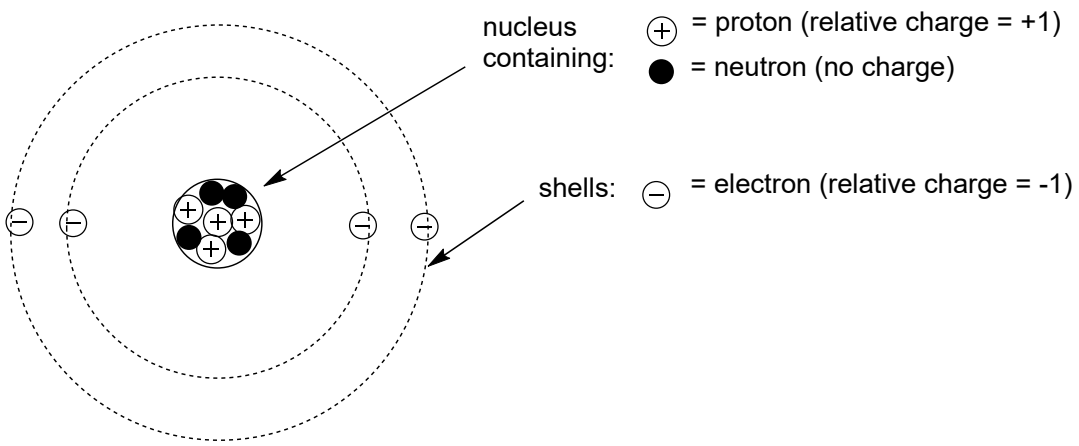
26 February – 27 February 2020

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.

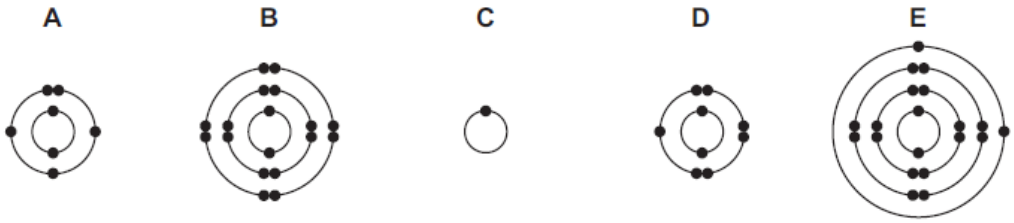
a) How many protons are there in an atom of sodium (symbol Na)?

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]

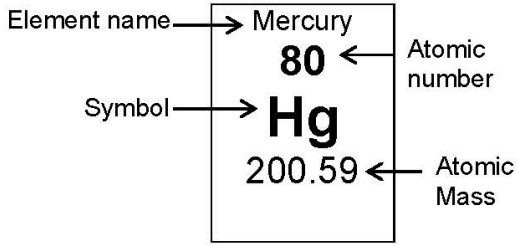
c) What would be the real mass, in kilograms, of $Nd_2Fe_{14}B$?

……

…… [2]

[Total: 25]

The Periodic Table of the Elements



1												13	14	15	16	17	18
Hydrogen 1 H 1.01	2																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		3	4	5	6	7	8	9	10	11	12	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)