RADLEY

2024 Academic Scholarship Examination Paper

COMBINED SCIENCE

CHEMISTRY

20 February – 21 February 2024

Time allowed – 30 minutes

Some of the questions in this paper will be new to you and are designed to introduce you to new concepts. Therefore, appropriate information will be provided.

Important Information:

- Read the information given for each question carefully.
- Answer all the questions in the spaces provided.
- If more space is required, please use the additional space at the end of the paper. ensuring that you clearly number your answers.
- A Periodic Table is provided at the end of the paper.

Marks: ……. / 35

1. The development of the periodic table is one of mankind's greatest achievements. Each atom is assigned its own number, the atomic number, starting with 1 for hydrogen (H) all the way to 118 for ununoctium (UuO) as you can see on the periodic table at the end of this paper. The atoms are also arranged in rows and columns with increasing atomic number from left to right. Atoms form elements and the various types of elements are separated into the metals and the nonmetals. The dividing line is the diagonal from boron (B, group 3) to astatine (At, group 7). Those right on the boundary are called the metalloids (semi-metals).

a) Predict if the following elements belong to the group of the metals, non-metals or semimetals. Tick the correct box.

	Atom (atomic number)	**Metal**	**Non-metal**	**Metalloid**
(i)	Sodium (11)			
(ii)	Silicon (14)			
(iii)	Nitrogen (7)			
(iv)	Tellurium (52)			
(v)	Neon (10)			

(5)

b) Consider the following formulae.

NH_3 - molecule		BH_3 – molecule		$ZnBr_2$ – compound
NaCl - compound		$CaSO_4$ – compound		O_2 - molecule
HCl - molecule		HNO_3 - molecule		$Mg(NO_3)_2$ - compound

Hydrogen sulfide is a foul-smelling and poisonous gas with the formula H_2S.

(i) Based on the table above deduce whether hydrogen sulfide, H_2S, is classified as a molecule or a compound.

.....

(1)

(ii) Explain your answer to the previous question (part (i)).

.....

.....

(1)

c) Atoms are the building blocks for elements and compounds. Elements and compounds can occur in all three states of matter.

(**i**) State the difference between an element and a compound.

.....

.....

(2)

(**ii**) List the three common states of matter.

.....

(1)

(**iii**) Which two physical quantities determine the state of matter of a substance?

.....

.....

(2)

(**iv**) Explain the change of the arrangement and movement of the particles in a substance when this substance melts. Contrast the before and after it melts.

.....

.....

.....

.....

(4)

(**v**) Energy is required to melt a substance. What is the energy used for?

.....

(1)

(**vi**) Explain why a bicycle tyre that is already fully filled with water would burst if more water was added whereas you can still add more air to an air-inflated bicycle tyre.

.....

.....

.....

.....

(2)

(**vii**) If you add a block of silver to a block of copper they do not mix. On the other hand fruit juice and water will mix. Can you explain this observation in terms of the particles involved?

.....

.....

.....

.....

(2)

(**viii**) What can you do to make the silver and copper blocks mix? Explain what happens in terms of their particles.

.....

.....

.....

.....

(3)

2. In Chemistry we use symbols to represent atoms. The letters tell us the type of atom (they are all listed in the periodic table), i.e. O stands for oxygen and any digits tell us the number of them. Small digits on the right close to the symbol tell us the number of atoms that are bonded together. This is called a molecule or compound. Big digits at the front of a formula tells as the number of individual molecules or compounds:

O_2 means that two oxygen atoms are bonded. Oxygen, O_2, is called a molecule.

2 O means two individual oxygen atoms.

2 O_2 means two individual oxygen molecules.

Guess what this means: $CaCO_3$ (it's called calcium carbonate)….

You may have guessed correctly: there are 1x calcium (Ca), 1x carbon (C) and 3x oxygen (O) atoms bonded together.

a) Can you deduce what this formula means: **K_2SO_4**

……

……

……

……

(2)

b) and what about this one: **$2\ Al_2O_3$**

……

……

……

……

(2)

c) ***What goes in comes out!*** The following question is about adding up.

In a chemical reaction we turn substances into other substances. In the process nothing is lost and all the atoms from the reactants (the substances you started with) end up in the products (what you get out at the end).

For example when hydrogen reacts with oxygen water is formed:
In symbol form this is:

$$H_2 + O_2 \rightarrow H_2O$$

You can readily see that there are two hydrogens (H) on both sides of the arrow, but there are two oxygens on the left (goes in) and only one oxygen on the right (comes out). A balanced equations is therefore:

$$\mathbf{2}\, H_2 + O_2 \rightarrow \mathbf{2}\, H_2O$$

We cannot take away, only add. Now try to do the same with the following equations:

(**i**) ..... Na + ... S → ..... Na_2S

(**ii**) ..... C_2H_6 + ... O_2 → ..... CO + ... H_2O

(iii) ..... Rb + ... H_2O → ..... RbOH + ... H_2

(6)

(iv) Copper can react with concentrated nitric acid to form the gas nitrogen monoxide.

$$3\, Cu + a\, HNO_3 \rightarrow b\, Cu(NO_3)_2 + c\, H_2O + d\, NO$$

What is the value of *a* when the equation is balanced?

a = ...

(1)

End of paper

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	[285] **Cn** copernicium 112	[286] **Uut** ununtrium 113	[289] **Fl** flerovium 114	[289] **Uup** ununpentium 115	[293] **Lv** livermorium 116	[294] **Uus** ununseptium 117	[294] **Uuo** ununoctium 118

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.