**MARKING SCHEME: CHEMISTRY (S4)**

**End of Year Examination: (100 marks)**

**End of Year Examination: 2020**

**SECTION A: (70 marks)**

1.a) 2 sub-atomic particles which are present in the nucleus of an atom: (**2 marks**)

-Proton

-Neutron

**(Give 1 mark for each answer)**

b) Describe the term **“atomic number”.** (**2 marks**)

The atomic number of an element is the number of protons in the nucleus.

2.a) Isotopes of an element: (**2 marks**)

Isotopes of an element are different atoms having the **same number of protons** but **with different number of neutrons**.

**(Give 1 mark for each underlined statement)**

b) 2 properties of a neutron: (**2 marks**)

-The electric charge of a neutron is zero

-The mass of a neutron is equal to that of a proton.

**(Give 1 mark for each answer)**

3. a) The process by which particles of an element are ionized in a mass spectrometer.(**2 marks**)

The vapourised sample passes through the ionization chamber where a **heated metal coil gives off electrons** which are attracted to the electron trap (positively charged plate). These **electrons knock off one or more electrons** from atoms or molecules to give positive ions.

**(Give 1 mark for each underlined statement)**

b)The process by which particles (isotopes) of an element are -Detection in a mass spectrometer: (**2 marks**)

A stream of ions makes it to the detector to **produce a current** which is a measure of **the number of ions** against mass per charge (m/z)

**(Give 1 mark for each underlined statement)**

(c) The relative atomic mass of boron in this sample. (**3 marks**)

= **10.80**

**(Give 2 marks for the working method and 1mark for the final answer)**

4. a)Relative atomic mass is the ratio of the average mass of atoms of a chemical element in a given sample of the atomic mass constant. (2 marks)

**(Accept other correct definitions)**

b) (i) The relative atomic mass of strontium. (**2 marks**)

= **87.71**

**(Give 1 mark for the working method and 1mark for the final answer)**

(ii) The most abundant isotope of strontium ion, Sr+ :

Number of protons= 38 **(0.5 mark)**

Number of electrons=37 **(0.5 mark)**

Number of neutrons=50 **(1 mark)**

5.a) Colour: Yellow**(1 mark**)

b) Origin of line emission spectra: (**2 marks**)

The emission spectrum of a chemical element or chemical compound is the spectrum of frequencies of electromagnetic radiation emitted due to an **atom or molecule making transition from a high energy state to a lower energy state**. Different lines are obtained due to the movement of electrons **from different initial energy states to reach different final energy states**.

c) The relationship between line emission spectra and energy levels in atoms: (**2 marks**)

The movement of an electron from different energy level to the lowest energy level is associated with a certain energy which corresponds to the characteristic colour of the wavelength.

**(Accept other correct answers)**

6. (a) Metals are generally good conductors of electricity: (**2 marks**)

Metals are good conductors of electricity because there are **free mobile electrons** around positive ions in the metal structure. These electrons carry charges from one position to another **under the influence of a potential difference**.

**(Give 1 mark for each underlined statement)**

(b) Most ionic crystals dissolve in water: (**2 marks**)

Most ionic crystals dissolve in water because the lattice bonds are broken when a certain amount of **energy (lattice energy) is absorbed by the crystal** and the resulting ions are then surrounded by water molecules with attraction between the ions and the partial charges on H2O.

This results in **liberation of energy (hydration energy)** which in turn enables more of the crystal to dissociate.

**(Give 1 mark for each underlined statement)**

7.(a) Formation of a covalent bond: (**2 marks**)

A covalent bond is formed when **each of the two atoms contributes one electron** to form a **pair for the bond between the two atoms**.

**(Give 1 mark for each underlined statement)**

b) A sigma bond (σ) is formed by **head to head overlap of atomic orbitals** whereas the pi (π) bond is formed by the **sideways overlap of two atomic orbitals**. (**2 marks**)

**(Give 1 mark for each underlined statement)**

8. a) Aluminium is good conductors of electricity because there are **free mobile electrons** around positive ions in the metal structure. (**2 marks**)

b) Sodium chloride dissolves in water because the lattice bonds are broken when a certain amount of **energy (lattice energy) is absorbed by the crystal** and the resulting ions are then surrounded by water molecules with attraction between the ions and the partial charges on H2O **to liberate hydration energy** (exothermic energy). (**2 marks**)

**(Give 1 mark for each underlined statement)**

c) Graphite is soft and slippery due to: (**2 marks**)

Graphite is formed by a layer structure in which **each carbon is linked to 3 other carbon atoms** by covalent bonds and the fourth electron of carbon is free to move. There are **no covalent bonds to attach carbon atoms between one layer to another**. So graphite becomes slippery.

**(Give 1 mark for each underlined statement)**

9.a) The first ionization energy is the minimum amount of energy required to **remove one mole of the most loosely bound electrons** of an element **in its gaseous state**. (**2 marks**)

**(Give 1 mark for each underlined statement)**

b) As you move across the second period, the first ionization energy increases due to the **increase in the number of protons in the nucleus** but with no increase in the number of shells.

This results in the **increase of the attraction of electrons towards the nucleus**. **(2 marks**)

**(Give 1 mark for each underlined statement)**

c) The first ionisation energy of the elements decreases as you go down group II of the periodic table.

This is due to **the increase in the number of shells** making the outermost shell electrons to be **farther away from the nu**cleus and become **less attracted to the nuclear charge** and therefore **more easily removed** with less energy. (**2 marks**)

**(Give 0.5 mark for each underlined statement)**

10.a) The atomic radius is the total distance from an atom’s nucleus to the outermost orbital of electrons. (**2 marks**)

b)i) The atomic radius decreases across the second period, the decrease in atomic radius is due to the **increase in the number of protons in the nucleus** but with no increase in the number of shells.

The net effect is the decrease in atomic radius because **the outermost shell electrons keep on being pulled more strongly to the nucleus** as you move across the period. (**2 marks**)

**(Give 1 mark for each underlined statement)**

ii) Down the group, **atomic radius increases** because **more shells are added as you move down the group**. (**2 marks**)

**(Give 1 mark for each underlined statement)**

11. (a) Balanced equation for the reaction between sodium and water:

2Na(s) + 2H2O(l) → 2NaOH(aq) + H2(g)  **(2 marks**)

**(Give 1 mark for unbalanced equation)**

(b) Equation:

2LiNO3(s) → 2LiNO2(s) + O2(g) (**2 marks**)

**(Give 1 mark for unbalanced equation)**

12. a) Sodium carbonate dissolves in water to produce OH- which in turn changes red litmus to blue. (**2 marks**)

b) **Lithium chloride is covalent** due to the small size of Li+ ion with a high charge. So **LiCl dissolves in a organic solvents** such as ethanol. (**2 marks**)

**(Give 1 mark for each underlined statement)**

13.a) Mg2+ ion possesses a higher charge than Na+ ion. So the electrostatic attraction between Mg2+ and O2- is greater than in NaCl. (**2 marks**)

b) The boiling points of group 17 elements increase down the group because the **inter-molecular van der waals forces of attraction** keep on increasing as you move down group 17 due to the **increase in the surface area**. (**2 marks**)

14. a)i) If the temperature is increased so much (eg to 1000 0C), the **equilibrium will shift to the left** to form N2 and H2 since the **forward reaction is effected with liberation of energy** (exothermic reaction) (**2 marks**)

**(Give 1 mark for each underlined statement)**

ii) If the pressure is increased very much (eg to 250 atmospheres), the **equilibrium will shift to the right** to form NH3 since the **forward reaction is effected with decrease in volume** (4 volumes produce 2 volumes). (**2 marks**)

**(Give 1 mark for each underlined statement)**

b) The importance of the iron catalyst in the production of ammonia is **to increase the rate of the reaction** at a low temperature **so that the yield of NH3 increases**. (**2 marks**)

**(Give 1 mark for each underlined statement)**

**SECTION B: Attempt three questions in this section (30 marks)**

15. a) Reactivity of beryllium, magnesium and calcium elements with water. (**3 marks**)

-Be reacts with hot steam at 700 0C to produce BeO and H2 gas.

-Mg reacts with steam to form Mg(OH)2 and H2 gas.

-Ca, Sr and Ba react vigorously with cold water to give corresponding hydroxides and H2 gas.

The reactivity increases as you move down the group.

**(Give 1 mark for each answer)**

b) Calcium carbide reacts with water to produce ethylene. (**2 marks**)

CaC2(s) + 2H2O(l) → C2H2 + Ca(OH)2(aq)

**(Give 1 mark for unbalanced equation)**

**(Accept the explanation in words if the equation is not provided)**

c) Reactivity of metals of group I and group II (**2 marks**)

-A group I metal is more reactive than a group II metal which is found in the same period.

For example, Na reacts with cold water whereas Mg does not react with cold water but with hot steam.

d) The elements Be, Mg and Ba belong to group II in the periodic table

i) Two chemical properties shown by these elements. **(1 mark)**

-They all react with acids to form hydrogen gas

-They all react with oxygen gas to form oxides.

**(Give 0.5 mark for each answer)**

(ii) The trends in solubility of the hydroxides. (1 **mark**)

-The solubility of group 2 hydroxides increases as you move down the group.

So Ba(OH)2 is more soluble than Mg(OH)2

(iii) Two properties in which Be differ from the rest of the group member: **(1 mark)**

-The oxides of Be are amphoteric while the oxides of the rest of group 2 elements are alkaline.

-BeC is covalent while carbides of other group 2 elements are ionic.

**(Accept other correct answers)**

**(Give 0.5 mark for each answer)**

16.a) Two properties in which carbon differs from the rest of group 14 elements. (**2 marks**)

-Carbon tetrachloride does not react with water while other members tetrachlorides of the group react with H2O

-Carbon forms catenation with other carbon atoms while other group members do not.

**(Accept other correct answers)**

**(Give 1 mark for each correct answer)**

b) Appropriate chemical equations, to explain similarities between tin and lead: (**2 marks**)

-Oxides of tin and lead are amphoteric:

Reaction with a base: PbO(s) +2OH-(aq) → PbO32-(aq)

Reaction with an acid: PbO(s) + 2H+(aq) → Pb2+(aq) + H2O(l)

The similar reactions occur for tin with acids and bases.

-Tetrachlorides of both tin and lead react with H2O:

PbCl4 + 2H2O → PbO2 + 4HCl

SnCl4 + 2H2O → SnO2 + 4HCl

c) Balanced equation between water and Silicon tetrachloride. (**2 marks**)

SiCl4 + 2H2O → SiO2 + 4HCl

**(Give 1 mark for unbalanced equation)**

d) Carbon tetrachloride is insoluble in water because: (**2 marks**)

CCl4 does not react with water because the carbon does not have vacant d-orbitals to accept (accommodate) incoming H2O molecules.

e) Equations to show the amphoteric nature of lead (II) oxide: (**2 marks**)

Reaction with a base: PbO(s) +2OH-(aq) → PbO32-(aq)

Reaction with an acid: PbO(s) + 2H+(aq) → Pb2+(aq) + H2O(l)

17.a) Standard enthalpy change of formation of a compound is the change of enthalpy during the formation of one mole of the substance from its constituent elements, with all the substances in their standard states. (**1 mark**)

b)i) The first law of thermodynamics states that energy cannot be created nor destroyed but it can be transformed from one form to another. (**2 marks**)

ii) The internal energy of a system is the total energy that includes potential and kinetic energy contained within a system.

The internal energy of a system can be increased by introduction of matter or by heat, or reduced when thermodynamic work is done by the system. (**1 mark**)

c) The 3 types of a thermodynamic systems and give an example for each type. (**3 marks**)

-An open system can exchange both energy and matter with the surroundings. Example: Boiling water in an open saucepan.

-A closed system can exchange only energy with the surroundings not matter. Example: Boiling water in a closed aluminium saucepan.

-An isolated system can neither exchange energy nor matter with the surroundings.

Example: Keeping hot water in a thermos flask.

**(Give 1 mark for each answer)**

d) The work done by a gas that expands by 6 litres against an external pressure of 4.5 atmospheres. (**3 marks**)

Work done = -P ∆V = - 101325 X 4.5 X 6

Work done = -**2,735,775 Joules**

**(Give 2 marks for the working method and 1 mark for the final answer)**

**(Accept other correct working methods)**

18.a) i) A Lewis acid is a chemical species that contains an empty orbital which is capable of accepting a pair of electrons from a Lewis base. (**2 marks**)

ii) Base according to the “Brønsted-Lowry theory”. (**2 marks**)

Brønsted-Lowry base is a solution that behaves as a proton (H+) acceptor.

b) Equation: HNO2 + H2O NO2- + H3O+

**H2O** is the conjugate base on the left side of the equation.

**NO2-** is the conjugate base on the right side of the equation. (**2 marks**)

**(Give 1 mark for each answer)**

c) An aqueous solution of AlCl3 has a PH less than 7 **(2 marks)**

Al3+ ion has a high charge with a small ion, therefore **it hydrolyses H2O molecules** to **produce H+ ions** in aqueous solution.

**(Give 1 mark for each underlined statement)**

d) -According to the Arrhenius theory, a strong acid is a substance that can dissociate to produce **many hydrogen ions** water.

-A weak acid is a substance that dissociates to produce **very few hydrogen ions** in water. **(2 marks)**

**(Give 1 mark for each answer)**

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