**UNIT3ACHE NAME:**

**ATOMIC STRUCTURE & BONDING: Answer all questions**

**PART A: MULTIPLE CHOICE QUESTIONS (10 marks)**

Q1. Three consecutive elements in the periodic table have the following values for the first, second and third ionisation energies:

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1st Ionisation  Energy (kJ mol─1) | 2nd Ionisation  Energy (kJ mol─1) | 3rd Ionisation  Energy (kJ mol─1) |
| Element X  Element Y  Element Z | 2087  502  744 | 3969  4568  1456 | 6130  6919  7737 |

From this information it can be concluded that element Z:

A. has the largest atomic radius of the three

B. belongs to Group 2 in the periodic table

C. is an inert gas

D. is the least reactive of the three.

Q2. Which one of the following chlorides is least hydrolysed by water at room temperatures?

A. OC*l*2

B. MgC*l*2

C. CC*l*4

D. A*l*C*l*3

Q3. Which statement **cannot** be true of two atoms with the same mass number?

A. They are isotopes of the same element

B. They have different numbers of protons

C. They have different numbers of neutrons

D. They are atoms of two different elements

Q4. Carbon dioxide is a gas at room temperature while silicon dioxide is a solid because

A. Van der Waals forces are much weaker than covalent bonds.

B. carbon dioxide contains double covalent bonds while silicon dioxide contains single covalent bonds.

C. carbon-oxygen bonds are less polar than silicon-oxygen bonds.

D. the relative formula mass of carbon dioxide is less than that of silicon dioxide.

Q5. The following table gives the electronegativities of some elements:

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **Electronegativity** | **Element** | **Electronegativity** |
| bromine | 2.8 | nitrogen | 3.0 |
| hydrogen | 2.1 | chlorine | 3.0 |
| carbon | 2.5 | oxygen | 3.5 |

Which one of the following bonds would be expected to be **most** polar?

A. C - H B. N - O

C. N – Cl D. H - Br

Q6. Gallium has an atomic mass of 69.8. If the only two isotopes of gallium found are 69Ga and 71Ga. What is the percentage of gallium - 69 that occurs naturally?

A. 20 % B. 40 % C. 60 % D. 80 %

Q7. An element **X** forms a compound of formula **X3N**. The electronic configuration of neutral atoms of element **X** could be

A. 2, 4 B. 2, 8, 2

C. 2, 7 D. 2, 5

Q8. Molecular solids, which are held together primarily by Van der Waals forces, usually

A. have very low melting points

B. have very high melting points

C. form hydrogen bonds

D. crystallise easily

Q9. Select the group in which all of the substances have covalent bonds.

A. diamond, iodine, carbon dioxide, sodium chloride.

B. hydrogen chloride, water, calcium oxide, paraffin wax.

C. graphite, steam, potassium chloride, ethanol.

D. ammonia, nitrogen, water, butane.

Q10. The diagram below represents the structure of a solid chemical substance.



The solid represented is most likely to be

A. silver.

B. iodine.

C. graphite.

D. sodium fluoride.

**END OF PART A**

**PART B: SHORT ANSWER QUESTIONS (15 marks)**

Q11. The table below shows some physical properties of the chlorides of some Period 3 elements.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **NaC*l*** | **MgC*l*2** | **PC*l*3** | **SC*l*2** |
| **Melting point / 0C** | 801 | 714 | ─92 | ─78 |
| **Boiling point / 0C** | 1465 | 1418 | 76 | 59 |
| **Electrical conductivity**  **of the solid** | poor | poor | poor | poor |
| **Electrical conductivity**  **of the liquid** | good | good | poor | poor |
| **pH of a water solution** | 7 | 7 | < 7 | < 7 |

1. Explain the large difference in the melting points of MgC*l*2 and SC*l*2.

(2 marks)

B. Explain the difference in the electrical conductivity of solid and liquid MgC*l*2.

(2 marks)

C. Would you expect a water solution of NaC*l* to be an electrical conductor? Explain.

(2 marks)

D. Would you expect a water solution of PC*l*3 to be an electrical conductor? Explain.

(2 marks)

E. Phosphorus forms more than one chloride. Give the name and formula of another chloride of phosphorus.

(2 marks)

Q12. An atom of a certain element **Q** has the electron configuration 2, 8, 6

A. In which Group of the Periodic table would you place **Q**? Explain.

(1 mark)

1. The formula of a hydride of **Q** is H2Q. Draw an electron dot diagram (Lewis structure) to represent this molecule. What shape is this molecule and give the size of the HQH bond angle?

|  |  |  |
| --- | --- | --- |
| **Lewis Structure** | **Shape** | **HQH bond angle** |
| (1 mark) | (½ mark) | (½ mark) |

C. Would you expect any dipole - dipole interactions between H2Q molecules? Explain.

(1 mark)

D. Would you expect any hydrogen bonding between H2Q molecules?

Explain.

(1 mark)

**PART C: EXTENDED ANSWER SECTION (15 marks)**

Q13. **“The valence - shell electron - pair repulsion theory (VSEPR Theory) can be used to explain the shapes of a variety of molecules and their bond angles“.**

1. Outline this theory.

(4 marks)

B. Use this theory to explain the shapes and bond angles in the following species

**HYDRONIUM ION (H3O+), BORON TRIFLUORIDE, AMMONIUM ION (NH4+),**

**CARBON DIOXIDE**

|  |  |  |
| --- | --- | --- |
|  | **SHAPE** | **BOND ANGLES** |
| **HYDRONIUM ION (H3O+)** |  |  |
| **BORON TRIFLUORIDE** |  |  |
| **AMMONIUM ION (NH4+)** |  |  |
| **CARBON DIOXIDE** |  |  |

(4 marks)

Q14. The moon lacks water and oxygen. The soil, however, contains a mineral called ilmenite, FeTiO3. It has been proposed that explorers on the moon could produce water from lunar soil by reducing it in a solar furnace at 1300 0C, initially using hydrogen transported from earth. Some of the water could then be electrolysed to yield oxygen.

**FeTiO3 + H2 ** **TiO2 + Fe + H2O**

**2H2O ** **2H2 + O2**

A 100 Kg sample of lunar soil, containing 4% ilmenite, is to be processed.

A. What would be the expected mass of water?

(4 marks)

B. If half the water is converted to oxygen, what volume would result at S.T.P.?

(3 marks)

**END OF TEST**

**UNIT3ACHE SOLUTIONS**

**ATOMIC STRUCTURE & BONDING: Answer all questions**

**PART A: MULTIPLE CHOICE QUESTIONS (10 marks)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1B** | **2C** | **3A** | **4A** | **5D** | **6C** | **7C** | **8A** | **9D** | **10B** |

**PART B: SHORT ANSWER QUESTIONS (15 marks)**

**Q11.**

**A. MgC*l*2 is an ionic compound while SC*l*2 is a molecular covalent compound. MgC*l*2 consists of a network of positive and negative ions held together by electrostatic forces, it requires a large amount of energy to break these bonds, hence the high melting point. In contradistinction SC*l*2, in the solid state consists of discrete molecules held together principally by dipole/dipole forces, these forces are much weaker than the ionic bonds in MgC*l*2 and these dipole/dipole forces require much less energy to break than the ionic bonds, hence the relatively low melting point in SC*l*2.**

**B. In solid MgC*l*2 the ions are locked (fixed positions) in a lattice and not free to move under an electrical potential difference (i.e. there are no mobile charges). In liquid MgC*l*2 the ions are no longer locked in a lattice and so can carry a charge (i.e. the charges are mobile)**

**C. Yes. In aqueous NaC*l* the ions are mobile and thus can carry a charge under the influence of an electric field.**

**D. Yes. From the data in the table, an aqueous solution of PC*l*3 has a pH < 7. It follows that it must react with water forming ions. These ions would move under an electrical potential difference and thus carry a charge.**

**E. PC*l*5; phosphorous pentachloride.**

**Q12.**

**A. Group 16; it has 6 valence electrons.**

**..**

**B. H : Q : H boomerang or V-shaped; 104.50**

**..**

**C. Yes. There is a difference in electronegativity between Q and H which makes the bond polar. The 2 non-bonding pairs of electrons give the molecule a V-shape. When the vectors (polar bonds) are resolved the sum of these vectors makes the molecule polar. Hence there will be dipole/dipole interactions between H2Q molecules.**

**D. No. Element Q is not N, O or F. Hydrogen bonding only exists between molecules where H is directly bonded to one of these 3 (N, O or F) very small electronegative elements.**

**PART C: EXTENDED ANSWER SECTION (15 marks)**

**Q13.**

**A. The theory states that the electron pairs in the valence shell will orientate themselves as far apart (repulsion) from each other in the 3-dimensions of space.**

**Double and triple bonds are treated the same as single bonds**

**The degree of repulsion for the electron pairs is greatest for non-bonding pair/non-bonding pair which is greater that the repulsion between non-bonding pair/bonding pair which in turn is greater than the repulsion between bonding pair/bonding pair.**

**This accounts for the reduction in the H-N-H bond angle in ammonia (NH3) from the tetrahedral bond angle of 109.50 to 1070 and a further reduction in the H-O-H bond angle in water (H2O) from the tetrahedral 109.50 to 104.50**

**B.**

|  |  |  |
| --- | --- | --- |
|  | **SHAPE** | **BOND ANGLES** |
| **HYDRONIUM ION (H3O+)** | **PYRAMIDAL** | **1070** |
| **BORON TRIFLUORIDE** | **TRIANGULAR PLANAR** | **1200** |
| **AMMONIUM ION (NH4+)** | **TETRAHEDRAL** | **109.50** |
| **CARBON DIOXIDE** | **LINEAR** | **1800** |

**Q14.**

**A. m(FeTiO3) = 100 x .04 Kg = 4 Kg = 4 x 103 g**

**quantity of known to moles of known (n =m/M)**

**n(FeTiO3) = 4 x 103 ÷ (55.85 + 47.88 + 3(16)) = 4 x 103 ÷ 151.73 = 26.36 mol**

**through the equation to moles of unknown**

**n(H2O) = n(FeTiO3) = 26.36 mol**

**moles of unknown to quantity of unknown (m = n x M)**

**m(H2O) = 26.36 x (2(1.008) + 16) = 26.36 x 18.016 = 474.9 g or**

**m(H2O) = 475 g (3 sig. figs.)**

**B. ½ n(H2O) = 26.36 ÷ 2 = 13.18 mol**

**moles of unknown to quantity of unknown (V = n x 22.41 @ S.T.P.)**

**V(H2O) = 13.18 x 22.41 L = 295.3 L**

**V(H2O) = 295 L (3 sig. figs.)**