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	2087	3969	6130
Element Y	502	4568	6919
Element Z	744	1456	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. OCl_2
B. $MgCl_2$
C. CCl_4
D. $AlCl_3$

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 ^{69}Ga and ^{71}Ga. 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 $\mathbf{X_3N}$. 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.

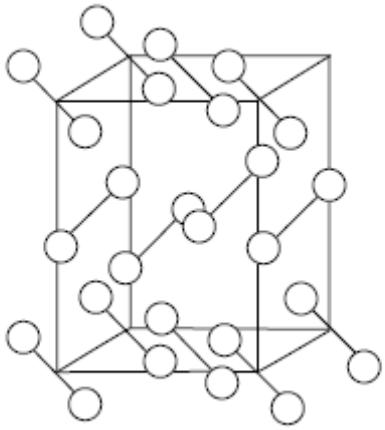
A. diamond, iodine, carbon dioxide, sodium chloride.

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.

	NaCl	**$MgCl_2$**	**PCl_3**	**SCl_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

A. Explain the large difference in the melting points of $MgCl_2$ and SCl_2.

(2 marks)

B. Explain the difference in the electrical conductivity of solid and liquid $MgCl_2$.

(2 marks)

C. Would you expect a water solution of $NaCl$ to be an electrical conductor? Explain.

(2 marks)

D. Would you expect a water solution of PCl_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)

B. The formula of a hydride of **Q** is H_2Q. 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 H_2Q molecules? Explain.

_____

_____

_____

(1 mark)

D. Would you expect any hydrogen bonding between H_2Q 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".**

A. Outline this theory.

(4 marks)

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

HYDRONIUM ION (H_3O^+), BORON TRIFLUORIDE, AMMONIUM ION (NH_4^+), CARBON DIOXIDE

	SHAPE	**BOND ANGLES**
HYDRONIUM ION (H_3O^+)		
BORON TRIFLUORIDE		
AMMONIUM ION (NH_4^+)		
CARBON DIOXIDE		

(4 marks)

Q14. The moon lacks water and oxygen. The soil, however, contains a mineral called ilmenite, $FeTiO_3$. 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.

$$FeTiO_3 + H_2 \longrightarrow TiO_2 + Fe + H_2O$$

$$2H_2O \longrightarrow 2H_2 + O_2$$

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. $MgCl_2$ is an ionic compound while SCl_2 is a molecular covalent compound. MgCl2 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 SCl2, 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 MgCl2 and these dipole/dipole forces require much less energy to break than the ionic bonds, hence the relatively low melting point in SCl2.

B. In solid $MgCl_2$ 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 $MgCl_2$ 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 NaCl 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 PCl_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. PCl_5; phosphorous pentachloride.

Q12.

A. Group 16; it has 6 valence electrons.

B. H : $\underset{\cdot\cdot}{\underset{\cdot\cdot}{Q}}$: H boomerang or V-shaped; 104.5^0

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 H_2Q 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 (NH_3) from the tetrahedral bond angle of 109.5^0 to 107^0 and a further reduction in the H-O-H bond angle in water (H_2O) from the tetrahedral 109.5^0 to 104.5^0

B.

	SHAPE	BOND ANGLES
HYDRONIUM ION (H_3O^+)	PYRAMIDAL	107^0
BORON TRIFLUORIDE	TRIANGULAR PLANAR	120^0
AMMONIUM ION (NH_4^+)	TETRAHEDRAL	109.5^0
CARBON DIOXIDE	LINEAR	180^0

Q14.

A. **$m(FeTiO_3) = 100 \times .04\ Kg = 4\ Kg = 4 \times 10^3\ g$**
quantity of known to moles of known (n =m/M)
$n(FeTiO_3) = 4 \times 10^3 \div (55.85 + 47.88 + 3(16)) = 4 \times 10^3 \div 151.73 = 26.36$ mol
through the equation to moles of unknown
$n(H_2O) = n(FeTiO_3) = 26.36$ mol
moles of unknown to quantity of unknown (m = n x M)
$m(H_2O) = 26.36 \times (2(1.008) + 16) = 26.36 \times 18.016 = 474.9$ g or
$m(H_2O) = 475$ g (3 sig. figs.)

B. **$\frac{1}{2}\ n(H_2O) = 26.36 \div 2 = 13.18$ mol**
moles of unknown to quantity of unknown (V = n x 22.41 @ S.T.P.)
$V(H_2O) = 13.18 \times 22.41$ L = 295.3 L
$V(H_2O) = 295$ L (3 sig. figs.)