

Test #1 (Atomic Structure & Bonding)

Weighting: 2%

Time: 50 minutes

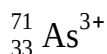
Name: **ANSWERS**

Mark = _____ / 46

Part 1: Multiple Choice Section

9 marks

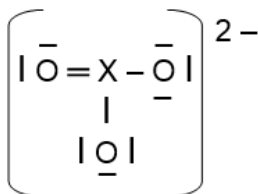
Answer by placing a cross through, or a circle around, the letter of the most correct answer.



1. The full symbol for a particular ion of arsenic-71 is _____.

Which of the following best describes the composition of this ion?

- ☒ **A. 33 protons, 38 neutrons and 30 electrons.**
- B. 33 protons, 38 neutrons and 33 electrons.
- C. 33 protons, 71 neutrons and 30 electrons.
- D. 38 protons, 33 neutrons and 38 electrons.
2. Consider the Lewis structure for a polyatomic anion of element X:



Element X is likely to be in:

- ☒ **A. group 14**
- B. group 15
- C. group 16
- D. group 17

24 valence electrons in diagram

18 from oxygen (6 each)

2 from elsewhere (-2 charge)

∴ 4 from X, ∴ group 14

3. Which of the following combinations of elements are listed in **increasing** order of electronegativity?

A. phosphorous, nitrogen, oxygen, sodium, magnesium

B. sodium, phosphorous, oxygen, nitrogen, fluorine

☒ **C. sodium, phosphorous, nitrogen, oxygen, fluorine**

D. sodium, magnesium, oxygen, nitrogen, fluorine

↑ across periods

↓ down groups

4. Which of the following correctly identifies the shapes of the following molecules?

	SiH_4	PH_3	H_2S	HCl
A.	planar	pyramidal	linear	linear
B.	tetrahedral	trigonal planar	linear	bent
C.	pyramidal	trigonal planar	bent	linear
D.	tetrahedral	pyramidal	bent	linear

5. Which of the substances listed below have both a trigonal planar shape and a dipole?

I	NH_3	pyramidal
II	H_2CO	trig planar & polar
III	SO_3	trig planar & non-polar
IV	PCl_3	pyramidal
V	COCl_2	trig planar & polar

- A. I and IV only
B. II and III only
C. II and V only
D. II, III and V only

6. The molecules hydrogen sulfide (H_2S), methanamine (CH_3NH_2), and oxygen (O_2), have similar molar mass. Which of the following lists the gases in **ascending** order of boiling point?

- A. H_2S , O_2 , CH_3NH_2
B. O_2 , H_2S , CH_3NH_2
C. O_2 , CH_3NH_2 , H_2S
D. CH_3NH_2 , H_2S , O_2

For molecules of similar size, strength of IMF is:
dispersion < dipole-dipole < hydrogen bonding

7. Which of the following statements is **incorrect** for an ionic substance?

- A. The substance will have a high melting point because of the strong electrostatic attraction between oppositely charged ions.
B. When heated sufficiently charged particles can move and allow the passage of an electric current through the substance.
C. When dissolved in water the ionic lattice breaks up and makes electrons available to allow the passage of an electric current through the solution.
D. When the ions in the lattice are forced to move, electrostatic repulsion tends to make the solid shatter.

It is the cations and anions that are the charge carriers in aqueous ionic solution

8. A covalent bond is best described as:
- A. a bond between two non-metallic elements.
 - B. the sharing of electrons between two atoms.
 - C. the attraction between the nuclei of adjacent atoms and their shared electrons.**
 - D. either a polar or non-polar bond.

9. The table below gives four consecutive ionisation energies (in MJ mol^{-1}) for an element in the third period of the Periodic Table.

1 st	2 nd	3 rd	4 th
0.425	3.058	4.418	5.883

Significant jump, \therefore one valence electron
Third period, \therefore three electron shells

The ground state electron configuration for atoms of this element is:

- A. 2,1
- B. 2,8,1**
- C. 2,8,4
- D. 2,8,8,1

End of Part One

Write all answers in the spaces provided.

Question 10**(5 marks)**

Consider the elements chlorine, magnesium, neon and phosphorus.

- (a) Rank the elements in **increasing** order of first ionisation energy.

Mg < P < Cl < Ne ✓

(1 mark)

- (b) Explain your reasoning for your ranking in (a) above.
Note that simply stating a trend is not an explanation.

Across (left to right) a period, first ionisation energy increases because valence electrons in the same shell are being attracted to a more positive nucleus.
∴ Mg < P < Cl (< Ar)

✓

✓

Down a group, first ionisation decreases because valence electrons are in a new shell at a greater distance from the nucleus
∴ Cl (< Ar) < Ne

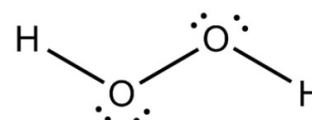
✓

✓

(4 marks)

Question 11**(4 marks)**

The Lewis structure for hydrogen peroxide, H₂O₂, is shown to the right. The O-O bond can be described as non-polar whereas the O-H bond can be described as polar. Explain the meaning of the terms polar and non-polar in relation to covalent bonds. In your response explain why there is a difference in polarity of the O-O and O-H bonds.



A non-polar bond is one in which there is an even distribution of charge.

✓

For example, in the O-O bond, the electrons are shared between two atoms of equal electronegativity, so they are evenly distributed between them.

✓

A polar bond is one in which there is an uneven distribution of charge.

✓

For example, in the O-H bond, the electrons are more strongly attracted to the O, which has greater electronegativity than H. The O, therefore, acquires a partial negative charge (δ⁻) and H acquires a partial positive charge (δ⁺).

✓

Question 12
(9 marks)

Complete the table given below by:

- drawing Lewis structures, representing all valence shell electron pairs as : or as –
- naming or drawing the molecular shapes
- identifying the molecules as either polar or non-polar

<i>Formula</i>	<i>Lewis structure</i>	<i>Molecular shape</i>	<i>Polar/non-polar</i>
CH_2Cl_2	$ \begin{array}{c} :\ddot{\text{Cl}}: \\ \\ \text{H}-\text{C}-\ddot{\text{Cl}}: \\ \\ \text{H} \end{array} $	tetrahedral	polar
PBr_3	$ \begin{array}{c} :\ddot{\text{Br}}: \\ \\ :\ddot{\text{Br}}-\text{P}: \\ \\ :\ddot{\text{Br}}: \end{array} $	trigonal pyramidal (or pyramidal)	polar
N_2O (NNO)	$ \begin{array}{c} \text{N}\equiv\text{N}-\ddot{\text{O}} \\ \text{or} \\ \ddot{\text{N}}=\text{N}=\ddot{\text{O}} \end{array} $	linear	polar

✓ each

Question 13**(3 marks)**

Consider the following information:

- element X is a silvery-grey solid at room temperature. It melts at 660°C and is a good thermal and electrical conductor
- element Y is a red liquid at room temperature and a non-conductor of electricity in any state
- element X and Y combine to form a compound that has a low melting point (98°C) and, when molten, is a non-conductor of electricity

- (a) Classify the compound of X and Y as ionic, metallic, molecular or covalent network.

Molecular

✓

(1 mark)

- (b) Provide supporting reasons for your classification in (a) above.

**Non-conductor of electricity when molten, so particles are not charged
 \therefore cannot be metallic or ionic.**

✓

**Low melting point, so particles not bound by strong bonds/forces
 \therefore cannot be covalent network.**

✓

By elimination, must be covalent molecular.

(2 marks)

Question 14**(4 marks)**

- (a) Explain what is meant by the term 'hydrogen bond'.

A hydrogen bond is an intermolecular force of attraction between a non-bonding pair of electrons on a O/N/F in one molecule and a partially positive hydrogen in an adjacent molecule (where it is covalently bonded to O/N/F)

✓✓

(2 marks)

- (b) Consider the substances listed below. Draw a circle around those that could possibly form a hydrogen bond with water.

hydrogen fluoride

phosphine (PH_3)

ammonia

trichloromethane (CHCl_3)

methanal (CH_2O)

2 correct ✓, 3 correct ✓✓ (2 marks)

Question 15**(6 marks)**

Consider the following substances and their melting points.

HBr -86°C

Br₂ 5°C

CCl₄ 90°C

Explain the difference in melting points for the each of the following pairs of substances:

(a) Br₂ and CCl₄

Both are non-polar molecules with only dispersion forces between molecules. ✓

Dispersion forces increase in strength with an increase in the number of protons and electrons in the molecule. ✓

CCl₄ has a greater number of electrons than Br₂ and so its dispersion forces are stronger. Greater energy is required to overcome these stronger forces of attraction and so CCl₄ has a higher boiling point. ✓

(3 marks)

(b) HBr and Br₂

Br₂ is a non-polar molecule with only dispersion forces between molecules. □

HBr is a polar molecule with dispersion and dipole-dipole forces between molecules. □

However, Br₂ has a greater number of electrons than HBr so its dispersion forces are stronger – in this case stronger than the dispersion and dipole-dipole forces between HBr molecules. □

Therefore, more energy needs to be supplied to overcome IMF between molecules of Br₂ than HBr.

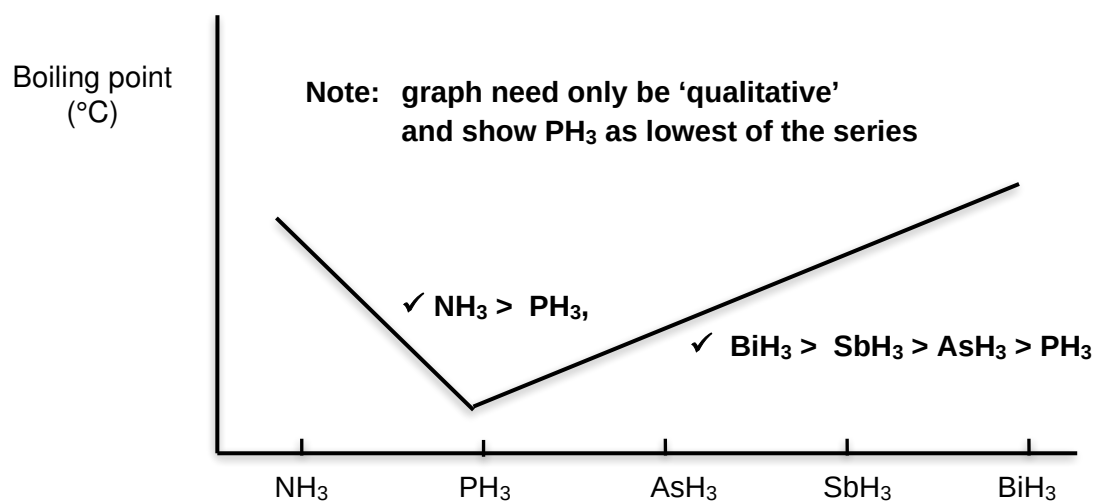
(3 marks)

Question 16

(6 marks)

Consider the hydrides of the group 15 elements.

- (a) On the axes below sketch a qualitative graph for the boiling points of the hydrides in this group.



(2 marks)

- (b) Account for the shape of your graph.

$\text{NH}_3 > \text{PH}_3$

N atom has high electronegativity so N-H bond is highly polar.

☐

Hydrogen bonds form between NH_3 molecules, so, despite its small size, NH_3 has a higher boiling point than PH_3 .

☐

$\text{BiH}_3 > \text{SbH}_3 > \text{AsH}_3 > \text{PH}_3$

Molecular polarity decreases, so dipole-dipole forces become weaker.

✓

However, the number of electrons per molecule increases, which increases the strength of dispersion forces and so boiling points increases.

☐

(4 marks)

End of Test