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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2024

91164 Demonstrate understanding of bonding, structure, properties and energy changes

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and other reference material are provided in the Resource Booklet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement TOTAL 10

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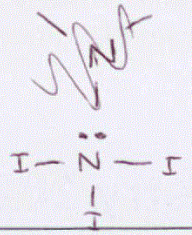
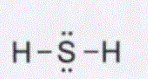
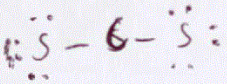
13

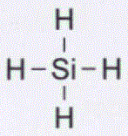
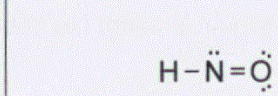
4
6
10

QUESTION ONE

(a) Draw the Lewis structure for each of the two blank molecules, and name their shapes.

Molecule	NI_3 (nitrogen triiodide)	H_2S (hydrogen sulfide)	CS_2 (carbon disulfide)
Lewis structure			
Name of shape	Tetrahedral	bent	linear
Approximate bond angle around central atom	109.5°	109.5°	180°

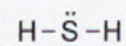
(b) Compare and contrast the shapes and bond angles of silicon tetrahydride, SiH_4, and azanone, HNO.

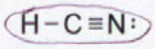
Molecule	SIH_4 (silicon tetrahydride)	HNO (azanone)
Lewis structure		

Tetrahydride ~~is~~ has a parent geometry of Tetrahedral and bond angle of 109.5. There are 4 bonding pairs and no lone pairs meaning the molecular geometry is also Tetrahedral. Azanone has a parent geometry of linear and bond angle of 180°. However as the Nitrogen atom has a lone pair, it repels the bonding pair for minimal repel according to the ~~VSEPR~~ VESPR theory. This state that the valence electrons of a molecule will repel as maximum distance to minimise the

(c) Hydrogen sulfide, H_2S, and hydrogen cyanide, HCN, molecules have a different shape, but they both have the same polarity.

The Lewis structure of both of these molecules are shown below:

hydrogen sulfide 

hydrogen cyanide 

(i) Circle the word below which identifies the polarity of both H_2S and HCN.

Polar **Non-polar**

(ii) Justify your choice of polarity by:

- explaining the links between the bonding and structure of each substance, and
- relating this to how the polarity of a molecule is determined.

The polarity of the molecule is determined by the lone pairs

(d) Methanamine, CH_3NH_2, is used widely in the production of pharmaceuticals, fungicides, insecticides, cleaning agents, and in the fabric industry.

Although hydrogen cyanide, HCN, is highly poisonous, it can be used to produce methanamine, as shown in the reaction below.

$$HCN(g) + 2H_2(g) \rightarrow CH_3NH_2(g) \quad \Delta_r H = -158 \text{ kJ mol}^{-1}$$

(i) Calculate the mass of methanamine formed when 1890 kJ of energy is released.

$M(CH_3NH_2) = 31.0 \text{ g mol}^{-1}$

$n = \frac{m}{M}$ - mass / - Mole

$1890 = \frac{m}{31.0}$

n = number of moles

m = mass

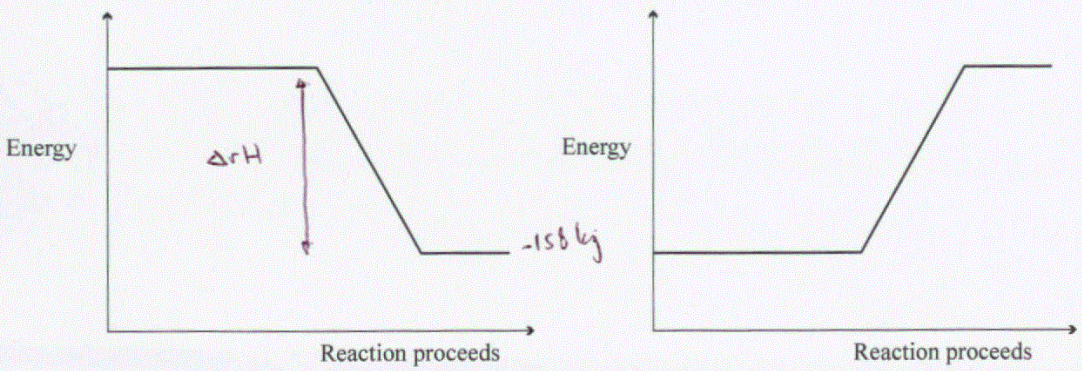
M = Molar Mass

m = ?

M = 31.0

n = ?

(ii) Choose the correct energy diagram that represents the reaction above and label it with the information provided in the equation.



QUESTION TWO

(a) Complete the table below for each substance in their solid state.

Solid	Melting point (°C)	Type of solid	Type of particle	Attractive forces between particles
$SiO_2(s)$ (silicon dioxide)	1700	Covalent Network solid	Atoms	~~Cov~~ covalent bonds
$SiCl_4(s)$ (silicon tetrachloride)	−69 ?	Molecular solid	Molecules	Intermolecular forces
$CuCl_2(s)$ (copper (II) chloride)	620	Molecular Solid	Molecules	Intermolecular forces
$Al(s)$ (aluminium)	660	Metalic Solid	Atoms	Metalic bonds

(b) Both SiO_2 and $SiCl_4$ contain silicon, but $SiCl_4$ has a considerably lower melting point.

Explain why there is a difference in melting point for these substances.

SiO_2 is a covalent Network Solid made up of atoms and held together by covalent bonds. These bonds are structured in a 3d lattice shape which means each atom is bonded to other atoms in the network. These bonds are very strong and require lots of energy to overcome, which is why is has a very high melting point. $SiCl_4$ is a molecular solid made up of molecules held together by weak intermolecular bonds. These bonds require little energy to overcome ~~so~~ the bonds will break between molecules melting ~~the~~ therefore it has a low melting point.

(c) Explain why silicon tetrachloride, $SiCl_4$, does not dissolve in water, but copper(II) chloride, $CuCl_2$, does.

Polar — Non polar — Polar

In your answer:

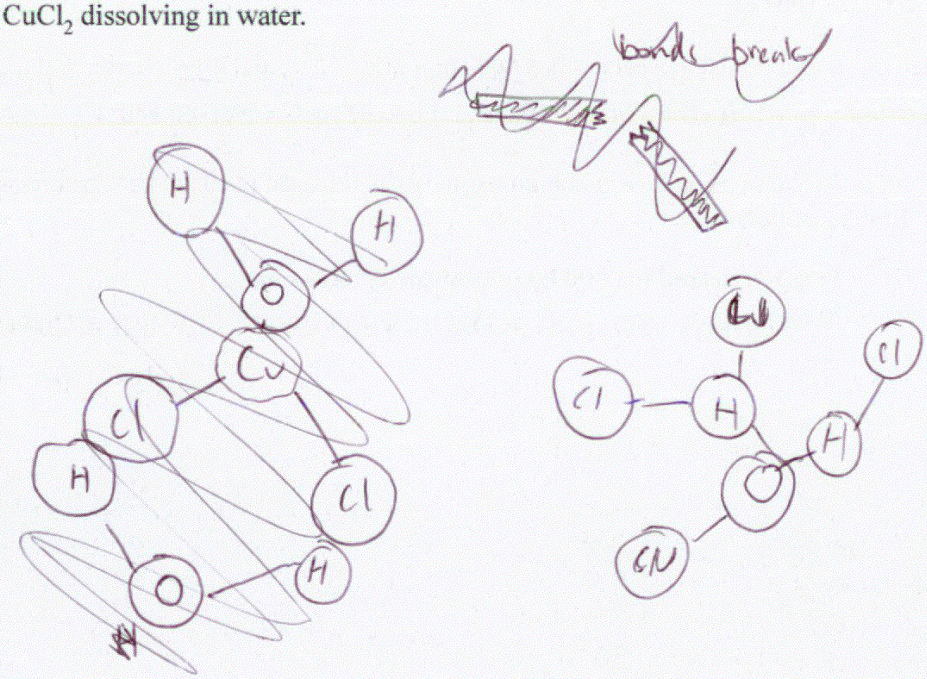
- link to their structure and bonding
- include the type of solvent that $SiCl_4$ will dissolve in, and why
- include a diagram to support your answer for $CuCl_2$.

Silicon tetrachloride is a non-polar molecule. When put in water it does not dissolve as the ~~forces~~ forces between molecules is ~~not great enough~~ greater than the ~~ones~~ ~~of~~ attraction forces between substances. This means that the ~~bond between~~ forces between molecules in SiCl ~~is greater than~~ the keeps the molecules together so that they do not dissolve. This is because water is a polar molecule and ~~SiCl~~ SiCl is non-polar, this they do not overcome the bonds between particles to dissolve and form bonds with eachother.

cannot

When dissolving Copper chloride in water the forces between particles is overcome to form bonds with water. This is because both H_2O and CuCl are polar, meaning they can form bonds and CuCl can dissolve.

Diagram to show $CuCl_2$ dissolving in water.



QUESTION THREE

Bottled gas supply in New Zealand is a 60% propane, C_3H_8, and 40% butane, C_4H_{10}, mix.
The combustion reactions for both propane and butane fuels are given below.

(a) Show by calculation how much more energy is released per 1.00 kg of propane compared to 1.00 kg of butane.

(i) Energy released by 1.00 kg of propane combustion

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\quad \Delta_r H = -2044 \text{ kJ mol}^{-1}$

$M(C_3H_8) = 44.1 \text{ g mol}^{-1}$

$m = \frac{1.000}{44.1}$ $\quad 0.6 \times 22.67$

$n = 22.67$

(ii) Energy released by 1.00 kg of butane combustion

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$ $\quad \Delta_r H = -2877 \text{ kJ mol}^{-1}$

$M(C_4H_{10}) = 58.1 \text{ g mol}^{-1}$

$m =$

(iii) Calculate how much more energy is released by 1.00 kg of propane than 1.00 kg of butane.

(b) The reaction of a hydrogen fuel cell is shown below. Hydrogen reacts with oxygen to produce water.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta_f H = -484$ kJ mol^{-1}

H–H	O=O	H–O–H
H_2	O_2	H_2O

Use the bond energies listed in the table, and the change in enthalpy (–484 kJ mol^{-1}) provided for the reaction, to calculate the average bond energy of the O–H bond.

Bond	Bond energy (kJ mol^{-1})
H–H	436
O=O	498

2(436) + 498 ⟶ 4x

1370 ⟶ 4x

−484

↑ ↑ this = more +484

1370 + 484 = 1854

1854 = 4x

463.5 = x

Average bond energy is 463.5 kjmol^{-1}

Question Three continues on the next page.

(c) 'Galvorn' is a newly developed form of carbon that is strong, light, and has good conductivity. With its clean manufacturing process and wide range of applications, it is anticipated that Galvorn could reduce the reliance on standard metals that are energy intensive to produce.

(i) As with graphite, Galvorn conducts electricity.

What requirement must Galvorn have to allow it to conduct electricity?

delocalised free moving electrons that can conduct the current.

(ii) Aluminium, Al, is also a good conductor of electricity, and it is malleable (can be pressed into shapes). These properties enable it to be used extensively in overhead power lines and for components and shells in smartphones and laptops.

Explain why aluminium, Al, has these properties, and link it to the uses stated.

Refer to its structure and bonding.

Conducts electricity: ~~Aluminium is a metalic solid made up from atoms held together by non-directional metalic bonds. These non-directional bonds allow atoms to slide/move past eachother without disrupting the bonds, but allowing it to be malleable.~~

Aluminium is able to ~~be~~ conduct electricity as it has delocalised electrons / sea of electrons, that are free moving and allow electrical conductivity.

Malleable: Aluminium is a metalic solid ~~held together by non-directional~~ made up from atoms held together by non-directional mitalic bonds. This ~~bonds allow~~ non-directional bonds, allows atoms to slide past eachother without disrupting the bonds, but allowing it to be malleable. This is why it is used in electrical components and power lines.

- Aluminium has a 2d lattice shape.

Achievement

Subject: Chemistry

Standard: 91164

Total score: 10

Q	Grade score	Marker commentary
One	A3	The candidate was awarded A3 as they recognised the bond angle for a particular shape, identified polarity of molecules without giving the reason and were able to identify and label the energy change for an exothermic reaction on an enthalpy diagram.
Two	A4	The candidate was awarded A4 as they were able to state the particle type and attractive forces for most solids, explained the difference between the melting point of two solids linking their particle type and strength of forces and recognised that polarity was the reason for the solubility of an ionic and a non-polar substance in water.
Three	A3	The candidate was awarded A3 as they correctly calculated one step from the calculation in part a, calculated the bond energy of a missing bond in part b but failed to round and give units and were able to only give a vague description of metallic bonding in part c.