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Level 2 Chemistry 2022

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 is 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 – 12 in the correct order and that none of these pages is blank.

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

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

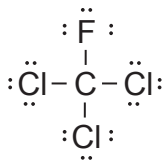
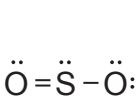
QUESTION ONE

Refrigerants are compounds that are used for cooling, such as in air conditioning units and refrigerators. Some commonly used refrigerants are shown in the table below.

(a) Draw the Lewis diagram (electron dot diagram) for the following molecules and name their shapes.

Molecule	**NH_3**	**CO_2**	**N_2**
Lewis diagram			
Name of shape			

(b) Chlorofluorocarbons (CFCs) were molecules commonly used as refrigerants in the 1970s and 1980s. One such example is trichlorofluoromethane, CCl_3F, commonly referred to as freon-11. It is shown in the table below, with another refrigerant, SO_2.

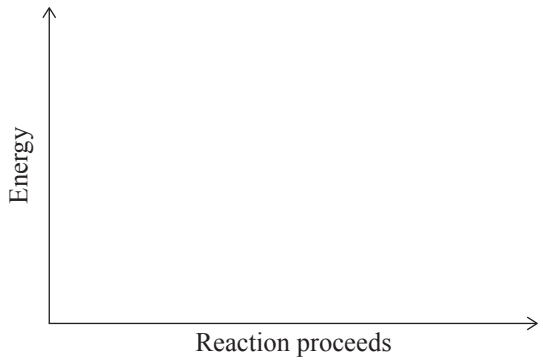
Lewis diagram		
Name	Freon-11 (CCl_3F)	Sulfur dioxide (SO_2)
Bond angle	109.5°	120°

Compare and contrast the shape and bond angles of freon-11 with SO_2.

(c) Freon-11, CCl_3F, works as a refrigerant in a refrigerator by evaporating, as shown in the equation below.

$$CCl_3F(\ell) \rightarrow CCl_3F(g) \qquad \Delta_r H = +25.2 \text{ kJ mol}^{-1}$$

(i) Draw a labelled energy diagram for the evaporation of freon-11, showing reactants, products, and the change in enthalpy ($\Delta_r H$).

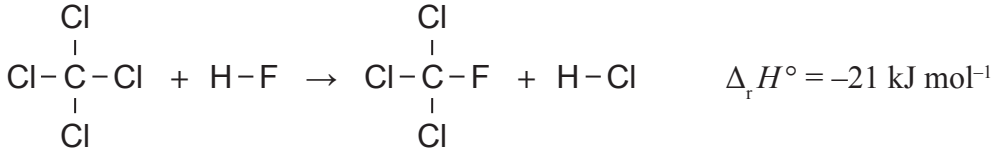


If you need to redraw your response, use the axes on page 11.

(ii) By referring to both the change in enthalpy and the attractive forces between particles in freon-11, explain how this process can be used to cool down a refrigerator.

QUESTION TWO

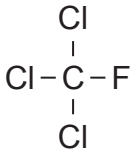
(a) Freon-11, $CCl_3F(g)$, is produced in the lab by the reaction of carbon tetrachloride, $CCl_4(g)$, with hydrogen fluoride, $HF(g)$, as shown in the reaction below.



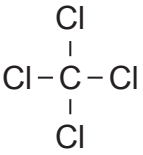
$\Delta_r H° = -21$ kJ mol^{-1}

(i) Use the change in enthalpy ($\Delta_r H°$) for the reaction above and the bond energies listed in the table below to calculate the average bond energy of the C–Cl bond.

Bond	Average bond energy (kJ mol^{-1})
C–F	485
H–F	567
H–Cl	431



Freon-11 (CCl_3F)



Carbon tetrachloride (CCl_4)

(ii) Circle the word in bold below that best describes the polarity of each molecule.

Freon-11 (CCl_3F)	**Polar**	**Non-polar**
Carbon tetrachloride (CCl_4)	**Polar**	**Non-polar**

(iii) Compare and contrast the factors that influence the polarity of these two molecules.

(b) Freon-11 was identified as contributing to the hole in the ozone layer and was banned in 1987. In the upper atmosphere, freon-11 causes the decomposition (breaking down) of ozone, $O_3(g)$.

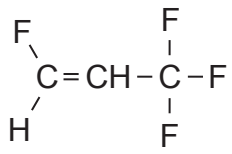
The overall reaction for the decomposition of ozone, $O_3(g)$ into oxygen gas, $O_2(g)$ is shown below.

$$2O_3(g) \rightarrow 3O_2(g) \qquad \Delta_r H = -285 \text{ kJ mol}^{-1}$$

Calculate the amount of energy released when 126 g of ozone, $O_3(g)$, is decomposed into oxygen gas, $O_2(g)$.

$M(O_3) = 48.0 \text{ g mol}^{-1}$

(c) A modern refrigerant, Compound A, $C_3H_2F_4(g)$, that neither damages the ozone layer nor acts as a greenhouse gas, is shown below.



(i) Classify compound A as either an ionic, molecular, metallic, or covalent network substance.

(ii) Refrigerants need to readily evaporate into a gas at room temperature to be effective.

Using your knowledge of structure and bonding, explain why Compound A is able to evaporate at room temperature.

QUESTION THREE

(a) Complete the following table for the substances in their solid states.

Solid	Type of solid	Type of particle	Attractive forces between particles
Freon-11 $CCl_3F(s)$			
Diamond $C(s)$			
Lithium bromide $LiBr(s)$			

(b) Carbon, $C(s)$, occurs naturally as both graphite and diamond. Graphite readily conducts electricity, while diamond is an electrical insulator.

Use your knowledge of structure and bonding to explain this difference in electrical conductivity.

(c) Solid lithium bromide, LiBr(*s*), readily dissolves in water, as shown in the equation below.

$$LiBr(s) \rightarrow Li^{+}(aq) + Br^{-}(aq) \quad \Delta_r H = -48.8 \text{ kJ mol}^{-1}$$

(i) Classify this process as exothermic or endothermic, with a reason.

(ii) The equation for the dissolving of solid potassium bromide, KBr(*s*), in water, is shown below.

$$KBr(s) \rightarrow K^{+}(aq) + Br^{-}(aq) \quad \Delta_r H = +19.9 \text{ kJ mol}^{-1}$$

Both lithium bromide, LiBr(*s*), and solid potassium bromide, KBr(*s*), are dissolved in 200 ml of water, in separate beakers. 20.0 g of LiBr is dissolved in the first beaker, resulting in an energy change.

Calculate the mass of solid potassium bromide, KBr(*s*), that would need to be dissolved in the second beaker in order to have an energy change of equal magnitude (size).

M(LiBr) = 86.8 g mol^{-1} M(KBr) = 119 g mol^{-1}

(iii) By considering the enthalpy change of each process, explain any difference in the resultant temperatures of each solution.

No calculations are needed in your answer.

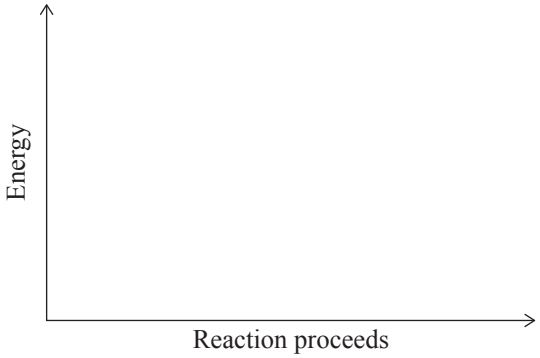
Question Three continues on the next page.

(iv) Use your knowledge of structure and bonding to explain why solid lithium bromide, LiBr(*s*), dissolves in water.

Use of a diagram is required in your answer to illustrate the dissolving process.

SPARE DIAGRAMS

If you need to redraw your response to Question One (c)(i), use the graph below. Make sure it is clear which answer you want marked.



Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER