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91164

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NZQA

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Level 2 Chemistry, 2016

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

9.30 a.m. Monday 21 November 2016
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 on the Resource Sheet L2–CHEMR.

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

Check that this booklet has pages 2–10 in the correct order and that none of these pages is blank.

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

Merit

TOTAL 15

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QUESTION ONE

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(a) Instant cold packs are useful for treating sports injuries on the field. They contain salts such as ammonium nitrate, NH_4NO_3. When the packs are activated, the salt dissolves in water, causing the temperature to decrease.

Circle the term that best describes the dissolving process.

endothermic **exothermic**

Give a reason for your choice.

This process is endothermic due to dissolving energy which requires heat hence heat is absorbed (endo) and temperature decreased of surrounding due to heat being absorbed (endo) U

(b) The equation for hydrating anhydrous copper sulfate is as follows:

$$CuSO_4(s) + 5H_2O(\ell) \rightarrow CuSO_4.5H_2O(s) \qquad \Delta_f H^\circ = -78.2 \text{ kJ mol}^{-1}$$

Circle the term that best describes this reaction.

endothermic **exothermic**

Give a reason for your choice.

This reaction is exothermic due to $\Delta_r H^\circ = -78.2 kJ mol^{-1}$ which is negative meaning heat energy is released and therefore exothermic U

(c) Pentane, C_5H_{12}, is a liquid at room temperature. It evaporates at 36.1°C in an endothermic process.

(i) Explain why the evaporation of pentane is an endothermic process.

In order for C_5H_{12} to change states from liquid to gas to evaporate, heat energy is required to break bonds and change state hence heat is absorbed resulting in this process to be endothermic. U

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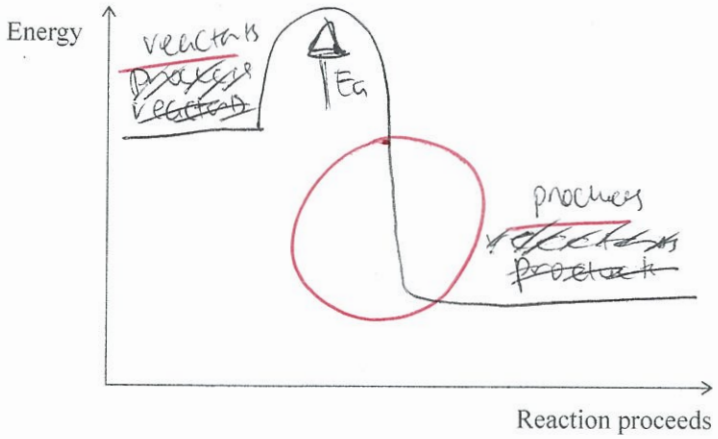
(ii) Draw, including labels, the energy diagram for the combustion of pentane, $C_5H_{12}(\ell)$.

Pentane combustion:

$$C_5H_{12}(\ell) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(\ell) \qquad \Delta_r H^\circ = -3509 \text{ kJ mol}^{-1}$$

Include in your diagram the reactants, products, and change in enthalpy.



(iii) Hexane, C_6H_{14}, like pentane, will combust (burn) in sufficient oxygen to produce carbon dioxide gas and water.

Hexane combustion:

$$2C_6H_{14}(\ell) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(\ell) \qquad \Delta_r H^\circ = -8316 \text{ kJ mol}^{-1}$$

Justify which alkane – pentane or hexane – will produce more heat energy when 125 g of each fuel is combusted in sufficient oxygen.

$M(C_5H_{12}) = 72.0 \text{ g mol}^{-1}$ $M(C_6H_{14}) = 86.0 \text{ g mol}^{-1}$

$n(C_6H_{14}) = \frac{m}{M} = \frac{125}{86} = 1.453488372$ moles

2 moles C_6H_{14} = 8316 kJ / 1 mole = 4158 kJ

1.453488372 moles = 6043.604651 kJ

$n(C_5H_{12}) = \frac{m}{M} = \frac{125}{72} = 1.736111111$ moles

2 moles = 8316 / 1 mole = 4158 kJ

1.736111111 moles = 7218.75 kJ

∴ pentane produces more heat energy (7218.25 kJ) than hexane which produces 6043.605 kJ. Pentane has 1175.145 kJ more heat than hexane!!

$2C_5H_{12} + 16O_2 \rightarrow 10CO_2 + 12H_2O$

M5

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QUESTION TWO

(a) Complete the table below by stating the type of substance, the type of particle, and the attractive forces between the particles in the solid for each substance.

Substance	Type of substance	Type of particle	Attractive forces between particles
$ZnCl_2(s)$ (zinc chloride)	ionic	ions	strong ionic bonds
$C(s)$ (graphite)	covalent	atoms	weak covalent bonds
$CO_2(s)$ (carbon dioxide / dry ice)	molecular	molecules	weak intermolecular ~~forces~~

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(b) Carbon (graphite) conducts electricity when it is solid, whereas zinc chloride, $ZnCl_2$, will not conduct electricity when solid, but will conduct when molten.

Justify this statement in terms of the particles, structure, and bonding for both substances.

Graphite is a covalent bond in a 2D lattice structure ~~that~~ where each C atom is covalently bonded to 3 other C atoms. Forces are weak. In order to conduct electricity, the substance requires free moving charged particles which graphite has in solid state. Due to having free moving charged particles in solid state as there is a delocalized e⁻ in graphite, graphite can conduct electricity in solid state.

Whereas ZnCl2 is an ionic solid held in a 3D lattice structure consisting of oppositely charged ions. In order to conduct electricity, ZnCl2 requires free moving charged particles which it does have but is held strongly into place with strong ionic bonding in solid state and therefore cannot conduct electricity. Though when ZnCl2 is dissolved in water or is in molten state, these charged ~~are~~ particles are no longer held in place with strong ionic bonding resulting in free moving charged particles to be present and ~~that~~ therefore ~~can conduct~~ in molten state but not

(c) Solid zinc chloride, $ZnCl_2(s)$, is soluble in water. Dry ice, $CO_2(s)$, is not readily soluble in water.

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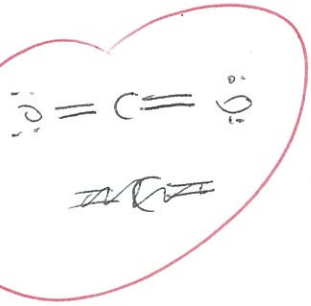
Justify these statements in terms of the particles, structure, and bonding of these substances.
You may include a diagram or diagrams in your answer.

ZnCl2 is ionic solid in a 3D lattice structure consisting of oppositely charged ions with strong ionic bonding. ZnCl2 is soluble in water as despite there being strong bonding between water molecules, the water molecules are more attracted to the positive (δ^+) + negative (δ^-) ions held in ZnCl2 causing it to break up into Zn^+ & Cl^- ions meaning ZnCl2 is soluble in water. Whereas CO2 is a molecular substance made up of non polar molecules. Non polar substances are only soluble in non polar solvents which means water which is polar cannot dissolve CO2. This is because the attraction between water is stronger than the attraction between the CO2 and water causing CO2 to not mix and not be soluble in water.

Space for diagrams



M5

QUESTION THREE

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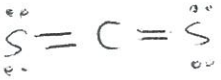
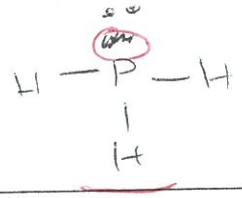
(a) (i) Draw the Lewis structure (electron dot diagram) for each of the following molecules, and name their shapes.

Molecule	H_2O	CS_2	PH_3
Lewis structure			
Name of shape	bent	linear	triangular pyramid
Approximate bond angle around the central atom	109.5°	180°	109.5°

(ii) Compare and contrast the shapes and bond angles of H_2O, CS_2 and PH_3.

H_2O has 4 regions of electron clouds around the central O giving it a tetrahedral arrangement. It has 2 bonding & 2 non bonding pairs and all 4 regions repel eachother to achieve maximum stability & minimum repulsion. Non bonding pairs repel bonding pairs more than the bonding pairs repel eachother as it's held closer to the nucleus. The non bonding pair contributes to the shape but is not considered part of it. This gives the shape a bent shape with an approximate angle of 109.5°

CS_2 has 2 regions of electron clouds around the central C often giving it a linear arrangement. All 2 regions repel eachother to achieve maximum stability & minimum repulsion. This gives it a bent shape at a approximate angle of 180°.

PH_3 has 4 regions of electron clouds similar to H_2O giving it a tetrahedral arrangement. It has 3 bonding & 1 non bonding pairs which all repel eachother for maximum stability & minimum repulsion. Non bonding pairs repel bonding pairs more than bonding pairs repel eachother as they're held closer to the nucleus. Non bonding pairs contribute to the shape but are not considered part of it. This gives it a triangular pyramid shape with an

(b) The Lewis structures for two molecules are shown.

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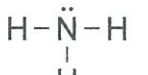
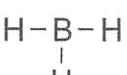
Molecule	 Ammonia	 Borane
Polarity of molecule	polar	non-polar

Ammonia, NH_3, is polar, and borane, BH_3, is non-polar.

Justify this statement.

NH3 has 3 bonding + 1 non-bonding pair around its central N atom giving it a tragular pyramid shape of an approximate angle of 107 NH3 has pola bonds due to the difference in electronegativity where N (δ^-) is more ~~polar bonds~~ electronegative than H (δ^+) causing unequal sharing of electrons and net dipoles. The overall molecule is also pola due to the shape of tricgular pyramid being asymmetrical causing net dipoles to not cancel out leaving a pola molecule ||

BH3 has 3 bonding and 0 non-bonding pairs around the central B atom giving it a triangular planar shape of an approximat angle of 120°. ~~BH3~~ BH3 has polar bonds due to the difference in electronegativity whe B (δ^-) is more electronegative than H (δ^+) causing unequal sharing of electrons and net dipoles. Due to the shape of triangular planar being symmetrical, the net dipoles can cancel eachother out leaving a nonpolar molecule overall. ||

C

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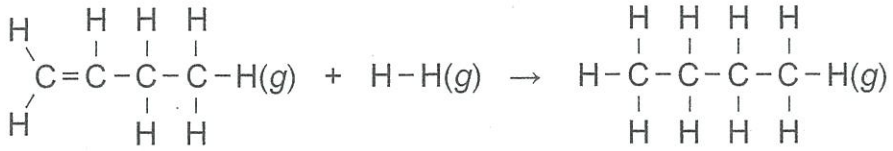
(c) Calculate the enthalpy change, $\Delta_r H^\circ$, for the reaction of but-1-ene gas, $C_4H_8(g)$, with hydrogen gas, $H_2(g)$, to form butane gas, $C_4H_{10}(g)$.

Use the average bond enthalpies given in the table below.



Bond	Average bond enthalpy / kJ mol^{-1}
C=C	614
C–C	346
C–H	414
H–H	436

Show your working and include appropriate units in your answer.

Bond breaking (+)	Bond making (−)
1 × C=C = 1 × 614 = 614	1 × H–H = 1 × 436 = 436
2 × C–C = 2 × 346 = 692	3 × C–C = 3 × 346 = 1038
8 × C–H = 8 × 414 = 3312	10 × C–H = 10 × 414 = 4140
= 4618	= 5614

+Bond breaking − bond making = $\Delta_r H^\circ$

∴ 4618 − 5614 = $\Delta_r H^\circ$

$\Delta_r H^\circ$ = −996 kJ mol^{-1} //

M5

Annotated Exemplar

Merit exemplar 2016

Subject:	Chemistry	Standard:	91164	Total score:	15

Q	Grade score	Annotation
1	M5	Both parts (a) and (b) are correct. In part (c)(i), the response outlines that energy is absorbed, but the type of bonds (intermolecular) is missing. In part (c)(ii), the Δ*H* label is missing, however, the reactants and products are correctly labelled. The calculation for hexane is correct, but the pentane calculation is not.
2	M5	Two rows and two columns are correct in the table in part (a). For part (b), the response outlines that charged particles are needed to conduct electricity, but for molten zinc chloride, the charged particles are not called ions or cat/anions. For part (c), the relative strengths are mentioned for CO_2, although expressed the opposite way round, as well as the polarity of water. No link to polarity of water attractions to ions in zinc chloride is made.
3	M5	Table completely correct in part (a)(i). The candidate just about explains the shapes and angles in part (b), but did not answer the question which asked for a comparison and a contrast. In part (b), the candidate states incorrectly that the bonds cancel, instead of dipoles or polarities cancelling. The candidate has included a partially correct process for the calculation, but including H—H bond under bond making, is a major error.