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Level 3 Chemistry 2020

91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

2.00 p.m. Friday 27 November 2020
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of thermochemical principles and the properties of particles and substances.	Demonstrate in-depth understanding of thermochemical principles and the properties of particles and substances.	Demonstrate comprehensive understanding of thermochemical principles and the properties of particles and substances.

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 relevant formulae are provided in the Resource Booklet L3–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 2–12 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.

TOTAL

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QUESTION ONE

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(a) (i) Identify all types of attractive forces between particles of the following substances in their liquid state.

Substance	Boiling point / °C	Attractive forces
Bromomethane, $CH_3Br(\ell)$	3.6	
Bromine, $Br_2(\ell)$	59	
Calcium bromide, $CaBr_2(\ell)$	1815	

With reference to the relative strength of the attractive forces between the particles in each substance, justify the following:

(ii) Calcium bromide has a higher boiling point than both bromomethane and bromine.

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(iii) Bromine has a higher boiling point than bromomethane.

(b) Solid sodium hydroxide, NaOH(*s*), readily dissolves in water:

$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$ $\Delta_r H^\circ = -44.5$ kJ mol^{-1}

Calculate the temperature change when 1.70 g of solid sodium hydroxide is dissolved in 35.0 g of water.

Assume the specific heat capacity of the sodium hydroxide solution is 4.18 J g^{-1} °C^{-1}.

Assume the mass of the sodium hydroxide solution is 36.7 g.

M(NaOH) = 40.0 g mol^{-1}

QUESTION TWO

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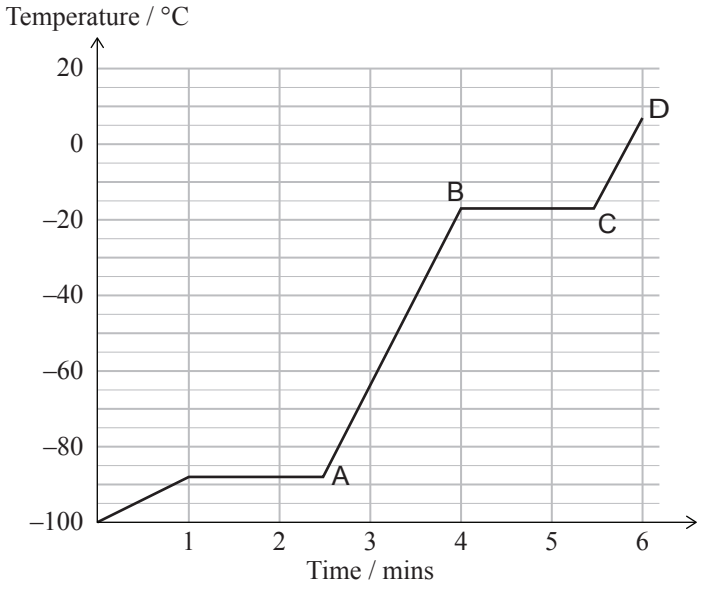
(a) The heating curve below shows the change in temperature as a sample of stibine, SbH_3, is supplied with a constant amount of heat over a time period of six minutes.

Heating curve for stibine



(i) Write the equation for the reaction that has an enthalpy change equal to the standard enthalpy of vaporisation, $\Delta_{vap}H°$, of SbH_3.

(ii) With reference to the heating curve for stibine, explain the physical changes between points A and D.

Your answer should refer to:

- energy and movement of particles
- intermolecular forces of attraction.

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(b) (i) Stibine can be oxidised according to the following reaction:

$$2SbH_3(g) + 3O_2(g) \rightarrow Sb_2O_3(g) + 3H_2O(\ell) \qquad \Delta_r H° = -1868 \text{ kJ mol}^{-1}$$

Calculate the standard enthalpy of formation of stibine, $\Delta_f H°(SbH_3)$.

$\Delta_f H°(Sb_2O_3) = -720$ kJ mol^{-1}

$\Delta_f H°(H_2O) = -286$ kJ mol^{-1}

(ii) Explain how the $\Delta_r H°$ provided in (i) would differ if the water was produced as a gas rather than a liquid.

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(c) When solid calcium, Ca(*s*), is added to a test tube of hydrochloric acid solution, HCl(*aq*), the calcium reacts vigorously. The test tube becomes hot, and bubbles of hydrogen gas, $H_2(g)$, are released. The reaction can be represented by the equation below:

$$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$$

Justify, in terms of the entropy changes of the system and the surroundings, why the reaction is spontaneous.

QUESTION THREE

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(a) (i) Complete the following table.

Symbol	Electron configuration (use *s*, *p*, *d* notation)
Mn	
As	
Cu^{2+}	

(ii) Explain why the radii of the Mg atom and the Mg^{2+} ion are different.

	Radius/pm
Mg atom	160
Mg^{2+} ion	72

(b) (i) Complete the table below.

	BrF_3	**PCl_6^-**
Lewis structure		
Name of shape		

Question Three continues on the following page.

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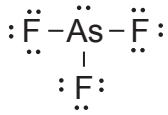
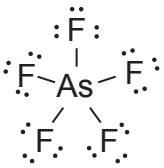
(ii) The Lewis structures and shape names for AsF_3 and AsF_5 are shown below.



Trigonal pyramidal



Trigonal bipyramidal

Compare and contrast the shapes and polarities of AsF_3 and AsF_5.

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(c) (i) Write the equation to show the reaction that has an enthalpy change equal to the first ionisation energy for the element arsenic, As.

(ii) Justify the difference in first ionisation energies for nitrogen, potassium, and arsenic.

Element	First ionisation energy / kJ mol^{-1}
Nitrogen, N	1407
Potassium, K	425
Arsenic, As	953

Extra space if required.
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