NZQA

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Level 3 Chemistry 2022

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

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 other reference material 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.

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

(a)   Complete the table below.

	$BrCl_5$	BrF_3
Lewis structure		
Name of shape		

(b)   Tellurium tetrafluoride, TeF_4, has the following Lewis structure and shape:

$$:\ddot{F}:$$
$$|$$
$$:\ddot{F}-\underset{..}{\overset{}{Te}}-\ddot{F}:$$
$$|$$
$$:\ddot{F}:$$

seesaw

Identify and explain the polarity of TeF_4.

Your answer should include an explanation of the shape.

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(c) (i) A student burnt 2.28 g of liquid methanol, $CH_3OH(\ell)$, to heat 100 g of water. The initial temperature of the water was 20.6 °C. Once all of the methanol had combusted, the student correctly determined the experimental enthalpy change for the combustion of liquid methanol, $\Delta_cH(CH_3OH(\ell))$, to be -68.6 kJ mol^{-1}.

The specific heat capacity of water is 4.18 J g^{-1} °C^{-1}

$M(CH_3OH) = 32.0$ g mol^{-1}

glass beaker

100 g of water

methanol burner

Calculate the final temperature that the 100 g of water must have reached in this experiment.

(ii) The standard enthalpy of combustion of liquid methanol is significantly more exothermic than the experimental value provided in part (i).

Explain TWO reasons for this difference.

QUESTION TWO

(a) Complete the following table.

Symbol	Electron configuration (use *s*, *p*, *d* notation)
Br	
V	
Ni^{2+}	

(b) The heating curve below shows the change in temperature as a sample of ammonia, NH_3, is supplied with a constant amount of heat over a time period of five minutes.

Heating curve for ammonia, NH_3
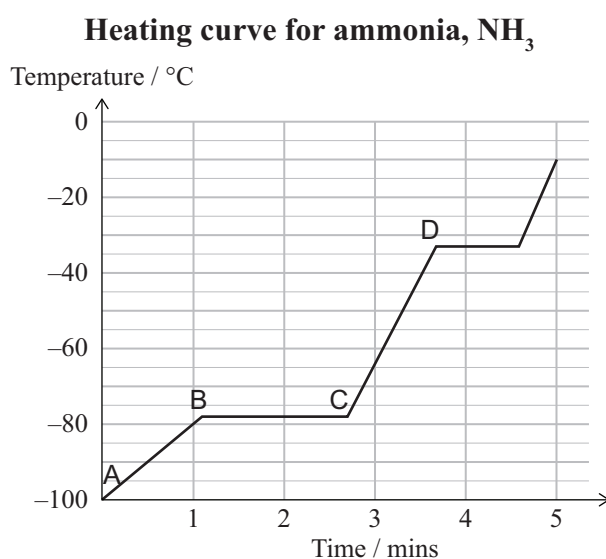
(i) Write the equation for the reaction that has an enthalpy change equal to the standard enthalpy of fusion, $\Delta_{fus}H°$, of NH_3.

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

Your answer should refer to:

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

(c) When diborane, B_2H_6, reacts with oxygen, O_2, it catches fire. The reaction is given below:

$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(\ell)$

(i) Calculate the standard enthalpy change, $\Delta_r H°$, for the reaction using the following data:

$\Delta_f H°(B_2H_6(g)) = +41.0 \text{ kJ mol}^{-1}$

$\Delta_f H°(B_2O_3(s)) = -1274 \text{ kJ mol}^{-1}$

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

(ii) Justify, in terms of the entropy changes of the system and the surroundings, why the reaction in part (i) occurs spontaneously.

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QUESTION THREE

(a) Explain why the radii of the Cl atom and the Cl⁻ ion are different.

Radius of Cl atom = 99 pm   Radius of Cl⁻ ion = 181 pm

(b) Justify why both first ionisation energy and electronegativity increase across a period, but atomic radius decreases across a period.

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

Substance	Molar mass / g mol^{-1}	Boiling point /°C	Attractive forces
N_2H_4	32.0	114	
BF_3	67.8	−102	
NOCl	65.5	−6	

(ii) Explain why N_2H_4 has the highest boiling point of the three molecules.

(iii)   Justify why BF_3 has a much lower boiling point than NOCl.

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