Chemical energetics – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.9

The enthalpy changes of formation, $\Delta H_f^{\ominus}$, of both PCl_3 and PCl_5 are exothermic.

PCl_3 reacts with chlorine.

$$PCl_3(l) + Cl_2(g) \rightarrow PCl_5(s) \qquad \Delta H^{\ominus}_{reaction} = -124\,kJ\,mol^{-1}$$

Which pair of statements is correct?

	statement 1	statement 2
A	$\Delta H^{\ominus}_{reaction}$ is less negative than $\Delta H_f^{\ominus}$ (PCl_5).	The Cl_2 bond energy is needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
B	$\Delta H^{\ominus}_{reaction}$ is more negative than $\Delta H_f^{\ominus}$ (PCl_5).	The Cl_2 bond energy is needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
C	$\Delta H^{\ominus}_{reaction}$ is less negative than $\Delta H_f^{\ominus}$ (PCl_5).	The Cl_2 bond energy is not needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.
D	$\Delta H^{\ominus}_{reaction}$ is more negative than $\Delta H_f^{\ominus}$ (PCl_5).	The Cl_2 bond energy is not needed in calculating $\Delta H^{\ominus}_{reaction}$ from enthalpies of formation.

2. Nov/2022/Paper_11/No.10

A student mixes $25.0\,cm^3$ of $0.350\,mol\,dm^{-3}$ sodium hydroxide solution with $25.0\,cm^3$ of $0.350\,mol\,dm^{-3}$ hydrochloric acid. The temperature increases by 2.5 °C. No heat is lost to the surroundings.

The final mixture has a specific heat capacity of $4.2\,J\,cm^{-3}\,K^{-1}$.

What is the molar enthalpy change for the reaction?

A $-150\,kJ\,mol^{-1}$

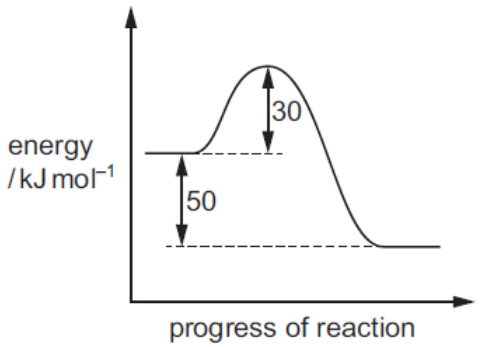
B $-60\,kJ\,mol^{-1}$

C $-30\,kJ\,mol^{-1}$

D $-0.15\,kJ\,mol^{-1}$

3. Nov/2022/Paper_12/No.9

The reaction pathway for the forward reaction of a reversible reaction is shown.



Which statement is correct?

A The activation energy of the reverse reaction is +80 kJ mol^{-1}.

B The enthalpy change for the forward reaction is +30 kJ mol^{-1}.

C The enthalpy change for the forward reaction is +50 kJ mol^{-1}.

D The enthalpy change for the reverse reaction is +30 kJ mol^{-1}.

4. Nov/2022/Paper_12/No.10

The enthalpy changes for the possible reactions W, X, Y and Z are given.

W	$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$	$\Delta H^\ominus = -56$ kJ mol^{-1}
X	$NaCl(aq) + H_2O(l) \rightarrow NaOH(aq) + HCl(aq)$	$\Delta H^\ominus = +56$ kJ mol^{-1}
Y	$2HI(g) \rightarrow H_2(g) + I_2(g)$	$\Delta H^\ominus = +11$ kJ mol^{-1}
Z	$H_2(g) + I_2(g) \rightarrow 2HI(g)$	$\Delta H^\ominus = -11$ kJ mol^{-1}

Which statement about the activation energies of these reactions is correct?

A X is greater than W; Z is greater than Y.

B X is greater than W; Y is greater than Z.

C W is greater than X; Z is greater than Y.

D W is greater than X; Y is greater than Z.

5. Nov/2022/Paper_12/No.16

Use relevant enthalpy changes from the tables to answer this question.

reaction	ΔH / kJ mol^{-1}
$C(s) + 2H_2(g) \rightarrow CH_4(g)$	–76
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$	–890
$CH_4(g) \rightarrow C(g) + 4H(g)$	1648
$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$	–105

bond	bond enthalpy / kJ mol^{-1}
H–H	436
C–C	350
C=C	610
C=O	805

Which value can be calculated for the enthalpy change for the following reaction?

$$2C(g) + 6H(g) \rightarrow C_2H_6(g)$$

A –2822 kJ mol^{-1}

B –2122 kJ mol^{-1}

C –1998 kJ mol^{-1}

D –1772 kJ mol^{-1}

6. Nov/2022/Paper_21/No.3(d)

(d) Sulfur, S_8, reacts with chlorine to form several different chlorides. The most common are S_2Cl_2 and SCl_2. SCl_2 forms when sulfur reacts with an excess of chlorine.

reaction **1** $S_8(s) + 4Cl_2(g) \rightarrow 4S_2Cl_2(l)$ $\Delta H_r = -58.2\,kJ\,mol^{-1}$

reaction **2** $S_2Cl_2(l) + Cl_2(g) \rightleftharpoons 2SCl_2(l)$ $\Delta H_r = -40.6\,kJ\,mol^{-1}$

(i) SCl_2 is a cherry-red liquid that reacts vigorously with water to form an acidic solution.

Use this information to deduce the bonding and structure shown by SCl_2.
Explain your answer.

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..... [2]

(ii) Calculate the enthalpy change of formation, ΔH_f, of $SCl_2(l)$. You may find it useful to use Hess's Law to construct an energy cycle.

enthalpy change of formation of $SCl_2(l)$, ΔH_f = ... $kJ\,mol^{-1}$
[2]

(iii) State the effect of a decrease in pressure on the position of equilibrium in reaction **2**. Explain your answer.

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Fig. 3.1 shows the two structural isomers of S_2Cl_2.

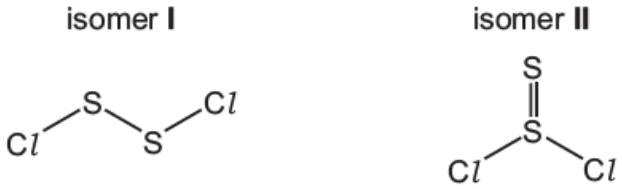

Fig. 3.1

(iv) Define the term structural isomer.

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..... [2]

(v) Suggest a value for the Cl–S–S bond angle in isomer **I**. Explain your answer.

bond angle = ... °

explanation .....

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[2]

(vi) Draw a dot-and-cross diagram to show the bonding in isomer **II**. Show outer shell electrons only.

[2]