A-Level Chemistry

Thermodynamics (Multiple Choice)

Question Paper

Time available: 16 minutes
Marks available: 16 marks

1. Which equation represents the process that occurs when the standard enthalpy of atomisation of iodine is measured?

A $\frac{1}{2} I_2(s) \rightarrow I(g)$ ⬭

B $I_2(s) \rightarrow 2I(g)$ ⬭

C $\frac{1}{2} I_2(g) \rightarrow I(g)$ ⬭

D $I_2(g) \rightarrow 2I(g)$ ⬭

(Total 1 mark)

2. Lattice enthalpy values can be obtained from Born–Haber cycles and by calculations based on a perfect ionic model.

Which compound shows the greatest percentage difference between these two values?

A CsF ⬭

B CsI ⬭

C LiF ⬭

D LiI ⬭

(Total 1 mark)

3. A reaction is exothermic and has a negative entropy change.

Which statement is correct?

A The reaction is always feasible ⬭

B The reaction is feasible above a certain temperature ⬭

C The reaction is feasible below a certain temperature ⬭

D The reaction is never feasible ⬭

(Total 1 mark)

4. Which one of the equations below represents a reaction that is feasible at all temperatures?

A $P(s) \rightarrow Q(s) + R(g)$ endothermic

B $2L(g) + M(g) \rightarrow 2N(g)$ exothermic

C $S(g) \rightarrow 2T(g)$ exothermic

D $A(g) + B(g) \rightarrow C(g)$ endothermic

(Total 1 mark)

5. Which one of the following reactions in aqueous solution has the most positive change in entropy?

A $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$

B $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$

C $[Cu(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Cu(EDTA)]^{2-} + 6H_2O$

D $[Cu(H_2O)_6]^{2+} + 2H_2NCH_2CH_2NH_2 \rightarrow [Cu(H_2NCH_2CH_2NH_2)_2(H_2O)_2]^{2+} + 4H_2O$

(Total 1 mark)

6. Refer to the following reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H^{\ominus} = -11 \text{ kJ mol}^{-1}, \qquad \Delta S^{\ominus} = +20 \text{ J K}^{-1} \text{ mol}^{-1}$$

Which one of the following statements is correct?

A This is a redox reaction.

B The reaction is **not** feasible below 298 K

C At equilibrium, the yield of hydrogen iodide is changed by increasing the pressure.

D At equilibrium, the yield of hydrogen iodide increases as the temperature is increased.

(Total 1 mark)

7. Which one of the following statements is **not** correct?

A The first ionisation energy of iron is greater than its second ionisation energy.

B The magnitude of the lattice enthalpy of magnesium oxide is greater than that of barium oxide.

C The oxidation state of iron in $[Fe(CN)_6]^{3-}$ is greater than the oxidation state of copper in $[CuCl_2]^-$

D The boiling point of C_3H_8 is lower than that of CH_3CH_2OH

(Total 1 mark)

8. This question is about the reaction given below.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

Enthalpy data for the reacting species are given in the table below.

Substance	CO(g)	$H_2O(g)$	$CO_2(g)$	$H_2(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	−110	−242	−394	0

Which one of the following statements is **not** correct?

A The value of K_p changes when the temperature changes.

B The activation energy decreases when the temperature is increased.

C The entropy change is more positive when the water is liquid rather than gaseous.

D The enthalpy change is more positive when the water is liquid rather than gaseous.

(Total 1 mark)

9. Using the information below, answer this question.

$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(g)$ $\Delta H^{\ominus} = +96$ kJ mol^{-1}, $\Delta S^{\ominus} = +138$ J K^{-1} mol^{-1}

	$Fe_2O_3(s)$	**$H_2(g)$**	**Fe(s)**
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	−822.0	0	0
$\Delta S^{\ominus}$ / J K^{-1} mol^{-1}	90.0	131.0	27.0

The standard entropy value for steam is

A +332 J K^{-1} mol^{-1}

B +189 J K^{-1} mol^{-1}

C +145 J K^{-1} mol^{-1}

D +85 J K^{-1} mol^{-1}

(Total 1 mark)

10. In which one of the following reactions is there a decrease in entropy?

A $[Fe(H_2O)_6]^{3+}(aq) + 3C_2O_4^{2-}(aq) \rightarrow [Fe(C_2O_4)_3]^{3-}(aq) + 6H_2O(l)$

B $[Cu(H_2O)_6]^{2+}(aq) + EDTA^{4-}(aq) \rightarrow [Cu(EDTA)]^{2-}(aq) + 6H_2O(l)$

C $[CoCl_4]^{2-}(aq) + 6H_2O(l) \rightarrow [Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq)$

D $Na_2CO_3(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$

(Total 1 mark)

11. This question relates to the equilibrium gas-phase synthesis of sulphur trioxide:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}	$S^{\ominus}$ / J K^{-1} mol^{-1}
$SO_3(g)$	−396	+257
$SO_2(g)$	–297	+248
$O_2(g)$	0	+204

This equilibrium, at a temperature of 585 K and a total pressure of 540 kPa, occurs in a vessel of volume 1.80 dm^3. At equilibrium, the vessel contains 0.0500 mol of $SO_2(g)$, 0.0800 mol of $O_2(g)$ and 0.0700 mol of $SO_3(g)$.

The standard entropy change for this reaction is

A −222 J K^{-1} mol^{-1}

B −195 J K^{-1} mol^{-1}

C −186 J K^{-1} mol^{-1}

D +198 J K^{-1} mol^{-1}

(Total 1 mark)

12. Which one of the following best explains why the lattice enthalpy of magnesium chloride is much larger than that of lithium chloride?

A Magnesium has a greater electronegativity than lithium.

B Magnesium ions have a greater polarising power than lithium ions.

C Magnesium ions have a greater ionic radius than lithium ions.

D Magnesium ions have a greater charge than lithium ions.

(Total 1 mark)

13. Which one of the following has the most covalent character?

A MgF_2

B $MgBr_2$

C AlF_3

D $AlBr_3$

(Total 1 mark)

14. The following information concerns the equilibrium gas-phase synthesis of methanol.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

At equilibrium, when the temperature is 68 °C, the total pressure is 1.70 MPa.
The number of moles of CO, H_2 and CH_3OH present are 0.160, 0.320 and 0.180, respectively.

Thermodynamic data are given below.

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}	$S^{\ominus}$ / J K^{-1} mol^{-1}
CO(g)	−110	198
H_2(g)	0	131
CH_3OH(g)	−201	240

The standard entropy change for this reaction is

A −220 J K^{-1} mol^{-1}

B +220 J K^{-1} mol^{-1}

C −89 J K^{-1} mol^{-1}

D +89 J K^{-1} mol^{-1}

(Total 1 mark)

15. The compound lithium tetrahydridoaluminate(III), $LiAlH_4$, is a useful reducing agent. It behaves in a similar fashion to $NaBH_4$. Carbonyl compounds and carboxylic acids are reduced to alcohols. However, $LiAlH_4$ also reduces water in a violent reaction so that it must be used in an organic solvent.

Which one of the following concerning the violent reaction between $LiAlH_4$ and water is **false**?

A A gas is produced.

B The activation energy for the reaction is relatively high.

C The reaction has a negative free-energy change.

D Aqueous lithium ions are formed.

(Total 1 mark)

16. Which one of the following has the most covalent character?

A MgF_2

B $MgBr_2$

C AlF_3

D $AlBr_3$

(Total 1 mark)