



A-Level Chemistry

Thermodynamics (Multiple Choice)

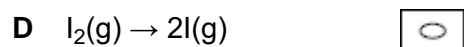
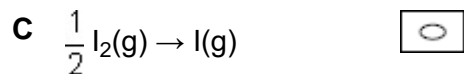
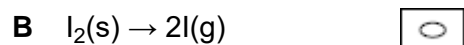
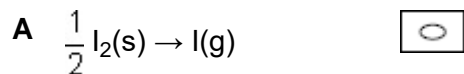
Question Paper

Time available: 16 minutes

Marks available: 16 marks

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



(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?



(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

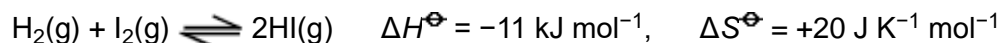
(Total 1 mark)

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



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.



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

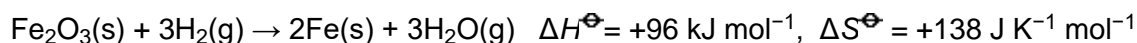
Substance	CO(g)	H ₂ O(g)	CO ₂ (g)	H ₂ (g)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-110	-242	-394	0

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 ₂ O ₃ (s)	H ₂ (g)	Fe(s)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-822.0	0	0
$\Delta S^\ominus / \text{J K}^{-1} \text{ mol}^{-1}$	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)

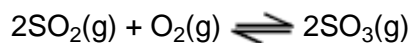
10.

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

- A $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) + 3\text{C}_2\text{O}_4^{2-}(\text{aq}) \rightarrow [\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$
- B $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + \text{EDTA}^{4-}(\text{aq}) \rightarrow [\text{Cu}(\text{EDTA})]^{2-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l})$
- C $[\text{CoCl}_4]^{2-}(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow [\text{Co}(\text{H}_2\text{O})_6]^{2+}(\text{aq}) + 4\text{Cl}^-(\text{aq})$
- D $\text{Na}_2\text{CO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow 2\text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

(Total 1 mark)**11.**

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



Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
$\text{SO}_3(\text{g})$	-396	+257
$\text{SO}_2(\text{g})$	-297	+248
$\text{O}_2(\text{g})$	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 dm³. At equilibrium, the vessel contains 0.0500 mol of $\text{SO}_2(\text{g})$, 0.0800 mol of $\text{O}_2(\text{g})$ and 0.0700 mol of $\text{SO}_3(\text{g})$.

The standard entropy change for this reaction is

- A $-222 \text{ J K}^{-1} \text{ mol}^{-1}$
- B $-195 \text{ J K}^{-1} \text{ mol}^{-1}$
- C $-186 \text{ J K}^{-1} \text{ mol}^{-1}$
- D $+198 \text{ J K}^{-1} \text{ mol}^{-1}$

(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.

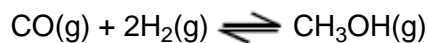
Which one of the following has the most covalent character?

- A MgF₂
- B MgBr₂
- C AlF₃
- D AlBr₃

(Total 1 mark)

14.

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



At equilibrium, when the temperature is 68 °C, the total pressure is 1.70 MPa.
The number of moles of CO, H₂ and CH₃OH present are 0.160, 0.320 and 0.180, respectively.

Thermodynamic data are given below.

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
CO(g)	-110	198
H ₂ (g)	0	131
CH ₃ OH(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)