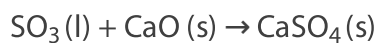


Entropy and spontaneity [19 marks]

1. [Maximum mark: 1]

What are the signs of $\Delta H^\ominus$ and $\Delta S^\ominus$ for this reaction that is non-spontaneous at high temperatures and spontaneous at low temperatures?

$$\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$$



	$\Delta H^\ominus$	$\Delta S^\ominus$
A.	+	+
B.	–	–
C.	–	+
D.	+	–

[1]

2. [Maximum mark: 1]

Which of the following statements is correct for the position of equilibrium of a reaction?

$$\Delta G^\ominus = -RT \ln K$$

- I. It will always shift to the right when temperature increases.
- II. If $\Delta G^\ominus < 0$, then $K > 1$ and products are favoured over reactants.
- III. If $\Delta G^\ominus = 0$, then $K=1$ and [reactants] and [products] are approximately equal.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

[1]

3. [Maximum mark: 1]

Which change results in the greatest decrease in entropy?

A. $\text{NaCl (s)} \rightarrow \text{NaCl (aq)}$

B. $2\text{NO}_2\text{(g)} \rightarrow \text{N}_2\text{O}_4\text{(g)}$

C. $\text{Mg (s)} + 2\text{HCl (aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$

D. $\text{CH}_4\text{(g)} + \text{H}_2\text{O (g)} \rightarrow \text{CO (g)} + 3\text{H}_2\text{(g)}$

[1]

4. [Maximum mark: 1]

Which combination is correct for a spontaneous reaction?

	$E^\ominus$	$\Delta G^\ominus$
A.	positive	positive
B.	positive	negative
C.	negative	positive
D.	negative	negative

[1]

5. [Maximum mark: 1]

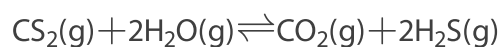
Which combination of values of ΔH and ΔS belongs to a reaction which is spontaneous at low temperatures but not spontaneous at high temperatures?

	ΔH	ΔS
A.	Negative	Negative
B.	Negative	Positive
C.	Positive	Positive
D.	Positive	Negative

[1]

6. [Maximum mark: 13]

Carbon disulfide, CS_2 , undergoes gas phase hydrolysis according to the overall equation



(a.i) Calculate the enthalpy change in this reaction from section 12 of the data booklet and the given values:

	$\text{CS}_2(\text{g})$	$\text{H}_2\text{S}(\text{g})$
$\Delta H_f^\ominus$	$+88.7 \text{ kJ mol}^{-1}$	$-20.6 \text{ kJ mol}^{-1}$

[2]

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(a.ii) Outline why you would expect the entropy change for this reaction to be quite small. [1]

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(a.iii) Neglecting any entropy change, use your answer to (a)(i), section 1 and section 2 of the data booklet to estimate the equilibrium constant, K_c , at 500 K.

(If you did not obtain an answer to (a)(i), use a value of $-50.0 \text{ kJ mol}^{-1}$, although this is not the correct answer.) [2]

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(a.iv) The concentrations of the species involved at equilibrium are:

$\text{CS}_2(\text{g})$	$\text{H}_2\text{O}(\text{g})$	$\text{CO}_2(\text{g})$	$\text{H}_2\text{S}(\text{g})$
$0.0400 \text{ mol dm}^{-3}$	$0.100 \text{ mol dm}^{-3}$	$x \text{ mol dm}^{-3}$	$2x \text{ mol dm}^{-3}$

Calculate the numerical value of X, the concentration of carbon dioxide at equilibrium, using your answer from (a)(iii).

[2]

(If you did not obtain an answer to (a)(iii), then use a value of 1.68×10^5 , although this is not the correct answer.)

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- (b) Deduce the molecular geometries of CS₂ and H₂S, and the reason why they are different.

Molecular geometry CS₂:

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Molecular geometry H₂S:

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Reason for difference:

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[2]

- (c) Sulfur has a number of natural isotopes and a sample of sulfur was enriched in $^{36}_{16}\text{S}$, to produce a mixture with the following composition:

Isotope	Percent
$^{32}_{16}\text{S}$	90 %
$^{33}_{16}\text{S}$	1 %
$^{34}_{16}\text{S}$	4 %
$^{36}_{16}\text{S}$	5 %

- (c.i) Calculate the relative atomic mass of this enriched sample, correct to two decimal places.

[2]

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- (c.ii) In naturally occurring sulfur, the relative abundance of $^{36}_{16}\text{S}$ is only 0.0100 %. Calculate the number of atoms of this isotope that would be present in 1.00 g of natural sulfur. Use sections 2 and 7 of the data booklet.

[2]

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Which changes would increase the rate of an exothermic reaction?

	Temperature	Particle size
A.	Increase	Decrease
B.	Increase	Increase
C.	Decrease	Increase
D.	Decrease	Decrease

[1]