Spontaneity and Driving Forces

Activity 1: Two Truths and a Lie

Question Group 1

Question 1

Consider these three statements. Two are true; one is false. Identify the false statement.

If a reaction is spontaneous under a certain set of conditions, then the reverse of the reaction will also be spontaneous.
A reaction can be spontaneous, yet occur very slowly.
A reaction that is spontaneous is one that sustains itself without continued external assistance.

Question 2

Consider these three statements. Two are true; one is false. Identify the false statement.

A reaction that is spontaneous is one that sustains itself without continued external assistance.
A spontaneous reaction is a reaction that happens very rapidly.
A reaction that is spontaneous may still need to be *activated* in order to occur.

Question 3

Consider these three statements. Two are true; one is false. Identify the false statement.

A reaction that is spontaneous may still need to be *activated* in order to occur.
If a reaction is not spontaneous under a certain set of conditions, then the reverse of the reaction will be spontaneous.
If a reaction takes place slowly, then it is not spontaneous.

Question Group 2

Question 4

Consider these three statements. Two are true; one is false. Identify the false statement.

If a reaction is spontaneous under a certain set of conditions, then the reverse of the reaction will also be spontaneous.
Some reactions may be spontaneous at low temperatures but not at relatively high temperatures.
A reaction that is exothermic is not guaranteed to be spontaneous; other factors must be considered.

Question 5
Consider these three statements. Two are true; one is false. Identify the false statement.

Some reactions may be spontaneous at high temperatures but not at relatively low temperatures.
If a reaction is spontaneous at one temperature, then it is spontaneous at all temperatures.
A reaction that is exothermic is not guaranteed to be spontaneous; other factors must be considered.

Question 6
Consider these three statements. Two are true; one is false. Identify the false statement.

A reaction can be spontaneous, yet occur very slowly.
A reaction that is spontaneous may still need to be *activated* in order to occur.
All exothermic reactions are spontaneous.

Question Group 3
Question 7
Consider these three statements. Two are true; one is false. Identify the false statement.

All exothermic reactions are spontaneous.
A reaction that is spontaneous is one that sustains itself without continued external assistance.
A reaction that is endothermic can still be spontaneous at certain temperatures if it involves an increase in entropy.

Question 8
Consider these three statements. Two are true; one is false. Identify the false statement.

Some reactions may be spontaneous at low temperatures but not at relatively high temperatures.
All endothermic reactions are non-spontaneous.
If a reaction is spontaneous under a certain set of conditions, then the reverse of the reaction will not be spontaneous.

Question 9
Consider these three statements. Two are true; one is false. Identify the false statement.

A reaction can be spontaneous, yet occur very slowly.

Some reactions may be spontaneous at high temperatures but not at relatively low temperatures.
A reaction with a negative value for ΔH will definitely be spontaneous.

Activity 2: Matching Pairs

This activity presents learners with 8 different terms that must be matched by meaning. Learners tap on the terms to select them and then tap on the Check Match button. The order of the terms is randomized. A mis-matched pair restarts the *game* and re-randomizes the order of the terms. The terms are ...

$\Delta H < 0$ and $\Delta S < 0$
$\Delta H > 0$ and $\Delta S < 0$
$\Delta H < 0$ and $\Delta S > 0$
$\Delta H > 0$ and $\Delta S > 0$
Reaction is spontaneous at all temperatures.
Reaction is spontaneous at relatively high temperatures.
Reaction is not spontaneous at any temperature.
Reaction is spontaneous at relatively low temperatures.

Activity 3: Reaction Analysis
Question Group 4
Question 10
Consider this reaction and its ΔH and ΔS values:

$$N_2H_{4(l)} \Longrightarrow N_{2(g)} + 2\ H_{2(g)}$$
$$\Delta H = -50.6\ kJ$$
$$\Delta S = +\ 331.5\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 11
Consider this reaction and its ΔH and ΔS values:

$$2\ Na_2O_{2(l)} + 2\ H_2O_{(l)} \Longrightarrow 4\ NaOH_{(s)} + O_{2(g)}$$
$$\Delta H = -109.0\ kJ$$
$$\Delta S = 132.2\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 12
Consider this reaction and its ΔH and ΔS values:

$$2\ CHCl_{3(l)} + O_{2(g)} \Longrightarrow 2\ COCl_{2(g)} + 2\ HCl_{(g)}$$
$$\Delta H = -353.3\ kJ$$
$$\Delta S = +336.3\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question Group 5
Question 13

Consider this reaction and its ΔH and ΔS values:

$$2\ CO_{(g)} \Longrightarrow 2\ C_{(s)} + O_{2(g)}$$
$$\Delta H = 110.5\ kJ$$
$$\Delta S = -89.4\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 14
Consider this reaction and its ΔH and ΔS values:

$$CO_{2(g)} \Longrightarrow C_{(s)} + O_{2(g)}$$
$$\Delta H = +393.5\ kJ$$
$$\Delta S = -3.05\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 15
Consider this reaction and its ΔH and ΔS values:

$$6\ CO_{2(g)} + 6\ H_2O_{(l)} \Longrightarrow C_6H_{12}O_{6(s)} + 6\ O_{2(g)}$$
$$\Delta H = 2802\ kJ$$
$$\Delta S = -262\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question Group 6
Question 16
Consider this reaction and its ΔH and ΔS values:

$$2\ NO_{(g)} + O_{2(g)} \Longrightarrow 2\ NO_{2(g)}$$
$$\Delta H = -120\ kJ$$
$$\Delta S = -150\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 17
Consider this reaction and its ΔH and ΔS values:

$$NH_{3(g)} + HCl_{(g)} \Longrightarrow NH_4Cl_{(s)}$$
$$\Delta H = -176.0\ kJ$$
$$\Delta S = -284.8\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 18
Consider this reaction and its ΔH and ΔS values:

$$CH_{4(g)} + 2\ O_{2(g)} \Longrightarrow CO_{2(g)} + 2\ H_2O_{(g)}$$
$$\Delta H = -890.4\ kJ$$
$$\Delta S = -242.2\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question Group 7
Question 19
Consider this reaction and its ΔH and ΔS values:

$$CaCO_{3(s)} \Longrightarrow CaO_{(s)} + CO_{2(g)}$$
$$\Delta H = +178.3 \text{ kJ}$$
$$\Delta S = +160.5 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 20
Consider this reaction and its ΔH and ΔS values:

$$Fe_2O_{3(s)} + 3\ H_{2(g)} \Longrightarrow 2\ Fe_{(s)} + 3\ H_2O_{(g)}$$
$$\Delta H = +\ 98.8 \text{ kJ}$$
$$\Delta S = +141.4 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 21
Consider this reaction and its ΔH and ΔS values:

$$Al_2O_{3(s)} + 2\ Fe_{(s)} \Longrightarrow 2\ Al_{(s)} + Fe_2O_{3(s)}$$
$$\Delta H = +851.5 \text{ kJ}$$
$$\Delta S = +38.5 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question Group 8
Question 22
Consider this reaction and its ΔH and ΔS values:

$$2\ NaHCO_{3(s)} \Longrightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$
$$\Delta H = +135.6\ kJ$$
$$\Delta S = +\ 338.9\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 23
Consider this reaction and its ΔH and ΔS values:

$$NaHCO_{3(s)} + HCl_{(aq)} \Longrightarrow NaCl_{(aq)} + H2O_{(l)} + CO_{2(g)}$$
$$\Delta H = +28.5\ kJ$$
$$\Delta S = +230\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 24
Consider this reaction and its ΔH and ΔS values:

$$N_{2(g)} + O_{2(g)} \Longrightarrow 2\ NO_{(g)}$$
$$\Delta H = +180.5\ kJ$$
$$\Delta S = +421.5\ J/K$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question Group 9
Question 25
Consider this reaction and its ΔH and ΔS values:

$$CaSO_{4(s)} \Longrightarrow Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$
$$\Delta H = -18 \text{ kJ}$$
$$\Delta S = -139.7 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 26
Consider this reaction and its ΔH and ΔS values:

$$2\ As_{(s)} + 3\ F_{2(g)} \Longrightarrow 2\ AsF_{3(l)}$$
$$\Delta H = -1643 \text{ kJ}$$
$$\Delta S = -316 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.

Question 27
Consider this reaction and its ΔH and ΔS values:

$$2\ H_{2(g)} + O_{2(g)} \Longrightarrow 2\ H_2O_{(l)}$$
$$\Delta H = -571.7 \text{ kJ}$$
$$\Delta S = -327.2 \text{ J/K}$$

Which phrase describes the spontaneity of this reaction?
Spontaneous at all temperatures.
Not spontaneous at any temperature.
Spontaneous only in high temperature range.
Spontaneous only in low temperature range.