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SECTION 1: EQUILIBRIUM

For questions 1 – 11 consider the following three reactions at 298 K.

I. $2\,SO_3\,(g) \leftrightarrow 3\,O_2\,(g) + 2\,S\,(s)$ K = 0.225 ΔH° =+ 791 kJ

II. $S\,(s) + O_2\,(g) \leftrightarrow SO_2\,(g)$ K = 225 ΔH° = -270 kJ

III. $2\,SO_3\,(g) \leftrightarrow O_2\,(g) + 2\,SO_2\,(g)$

1.) What is the equilibrium constant for a mixture of O_2, SO_3 and SO_2 gas (rxn. **III**)?

A) 75.5
B) 112
C) 1.1×10^{4}
D) 2.5×10^{-5}
E) 0.775

$2SO_3 \rightarrow 3O_2 + 2S$ ~~K=0.225~~ $\Delta H = 791$ kJ

$2S + 2O_2 \leftrightarrow 2SO_2$ ~~K = 225~~ (270)2

$2SO_3 \leftrightarrow O_2 + 2SO_2$

$K = \frac{[SO_2]^2[O_2]}{[SO_3]^2}$

2.) What is the value of the equilibrium constant for rxn **I** if at equilibrium the flask contains 0.236 atm SO_3, 0.500 atm O_2, and 0.01 g Sulfur after a temperature change.

A) 0.0909
B) 11.0
C) 1.63×10^{-5}
D) 6.25×10^{-2}
E) 2.24

3.) What change has occurred if the value of K for rxn **I** is found to be 0.552?

A) An increase in temperature.
B) A decrease in temperature.
C) An increase in pressure.
D) An increase in volume.
E) cannot be determined.

4.) Which is a suitable expression for the reaction quotient for the formation of SO_2 from the elements?

A) $P(O_2) / P\,(SO_2)$
B) $P(O_2)\,P^2\,(SO_2) / P(S)$
C) $P(O_2) / P^2\,(SO_2)P(S)$
D) $P\,(SO_2) / P(O_2)$
E) Nothing can be said with the information given.

$\frac{P_{SO_2}}{P_{O_2}}$

5.) What is ΔH° for reaction **III**?

A) 333 kJ
B) 251 kJ
C) 1.7×10^{3} kJ
D) 5 kJ
E) 76 kJ

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6.) Which is the best arrangement of the relative enthalpies of formation of compounds O_2, SO_3, and SO_2?

$SO_3 = -395.5$
$SO_2 = -270$
$O_2 = 0$

	A)	B)	C)	D)	E)
ΔH ↑	O_2	O_2	SO_3	SO_2	SO_2
	SO_3	SO_2	SO_2	SO_3	O_2
	SO_2	SO_3	O_2	O_2	SO_3

7.) What is the best prediction of ΔS° for reaction **I** at 298K?

ΔH (+)
ΔS (+)

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

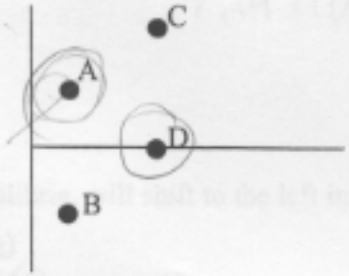
A) $\Delta S^\circ > 0$
B) $\Delta S^\circ = 0$
C) $\Delta S^\circ < 0$
D) $\Delta S^\circ \leq 0$
E) $\Delta S^\circ \geq 0$

8.) What can you say about reaction **I** at 298 K?

A) It is exothermic.
B) It is spontaneous.
C) It is not spontaneous.
D) It is at equilibrium.
E) It releases heat.

9.) The correct plot for lnK vs 1/T for reaction **I** would pass through which pair of points (fill in both points on scantron sheet)?

$$\ln K = -\frac{\Delta H^\circ}{R}\left(\frac{1}{T}\right) + \frac{\Delta S^\circ}{R}$$



10.) From which of the following starting conditions would it be impossible for equilibrium to be achieved for reaction **II**?

A) Pure SO_2 (g).
B) A mixture of SO_2 (g), O_2 (g), and S (s).
C) A mixture of SO_2 (g) and O_2 (g).
D) Pure O_2 (g) and S (s).
E) Equilibrium can be achieved from any of these starting conditions.

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11.) Which occurs when adding S (s) to the equilibrium described by reactions **I, II** and **III**?

A) A decrease in the pressure of $SO_3(g)$.
B) A decrease the pressure of $SO_2(g)$.
C) An increase in the value of the equilibrium constant.
D) An increase in the total pressure of the system.
E) No change in the equilibrium.

Continue with the next question:

12.) For the reaction

$A(l) + 2D(g) \rightarrow 3X(g) + Z(s)$
having $\Delta G^\circ = -2400$ kJ at 25°C, the equilibrium mixture _____.

A) will consist almost exclusively of A and D.
B) will consist almost exclusively of A and Z.
C) will consist almost exclusively of X and Z.
D) will consist of significant amounts of A, D, X, and Z.
E) has a composition predictable only if one knows T and ΔH° and ΔS°.

13.) The equilibrium constant for the reaction below at 25°C is 4.8×10^{-6}. Calculate the equilibrium concentration (mol/L) of Cl_2 (g) if the initial concentration of ICl (g) is 1.33 mol/L. There is no I_2 or Cl_2 initially present.

$2ICl(g) \leftrightarrow I_2(g) + Cl_2(g)$
$1.33-x \quad +x \quad +x$

$4.8 \times 10^{-6} = \frac{[I_2][Cl_2]}{[ICl]^2} = \frac{x^2}{(1.33-x)^2}$

$2.19 \times 10^{-3} = \frac{x}{1.33-x}$

$x = 2.91 \times 10^{-3}$

A) 2.9×10^{-3}
B) 5.8×10^{-3}
C) 3.2×10^{-6}
D) 6.4×10^{-6}
E) 343

14.) Which of the following equilibria, will shift to the left in response to a decrease in volume?

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A) $H_2(g) + Cl_2(g) \leftrightarrow 2\,HCl(g)$
B) $2\,SO_3(g) \leftrightarrow 2\,SO_2(g) + O_2(g)$
C) $N_2(g) + 3\,H_2(g) \leftrightarrow 2\,NH_3(g)$
D) $4\,Fe(s) + 3\,O_2(g) \leftrightarrow 2\,Fe_2O_3(s)$
E) $2HI(g) \leftrightarrow H_2(g) + I_2(g)$