This print-out should have 18 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points

In general, decreasing the temperature makes which phase transitions more likely to occur?

1. condensation, fusion, deposition

2. condensation, freezing, deposition **correct**

3. evaporation, deposition, freezing

4. sublimation, condensation, freezing

5. evaporation, fusion, sublimation

Explanation:

Phase changes are equilibrium processes and are thus temperature dependent. Also, the ΔH and ΔS always have the same sign. Lowering the temperature makes exothermic phase transitions more likely - freezing, condensation and deposition.

002 10.0 points

Which of the following is a possible combination of values for $\Delta H_{lattice}$, $\Delta H_{hydration}$ and $\Delta H_{solution}$, respectively, for a salt whose dissolution is endothermic.

1. $-450,\ +400,$ and $-50\ \text{kJ}\cdot\text{mol}^{-1}$,

2. $-900,\ -900,$ and $-1800\ \text{kJ}\cdot\text{mol}^{-1}$,

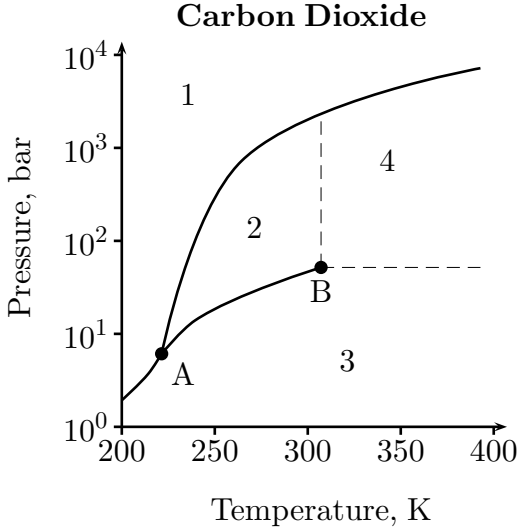
3. $+640,\ -620,$ and $+20\ \text{kJ}\cdot\text{mol}^{-1}$, **correct**

4. $+550,\ -480,$ and $+1030\ \text{kJ}\cdot\text{mol}^{-1}$,

Explanation:

$\Delta H_{solution} = \Delta H_{lattice} + \Delta H_{hydration}$ - the problem stipulates that $\Delta H_{solution}$ be positive (endothermic) and this limits the values the other two terms can have.

003 10.0 points



A sample of carbon dioxide is stored at 10^4 bar and 250 K. This sample is then decompressed to 10^0 bar at constant temperature. Then, at constant pressure it is heated to 400 K. Next, it is compressed at constant temperature to 200 bar. According to the phase diagram, how many phase transitions has the carbon dioxide gone through, and what is its final state?

1. 3, supercritical fluid

2. 3, gas

3. 2, supercritical fluid **correct**

4. 2, gas

5. 2, liquid

Explanation:

Navigate through the diagram through each process. In the first decompression, the solid is decompressed and becomes a liquid and then a gas (2 phase transitions). Upon heating, it becomes a supercritical fluid (no phase transitions).

004 10.0 points

30.2 g of glycerine ($C_3H_8O_3$) are dissolved in 150 g of water. What is the boiling point of the solution? (K_b of water = 0.515°C/m)

1. 101.13°C **correct**

2. 1.13°C

3. 0.104°C

4. 100.10°C

5. 103.52°C

Explanation:
$m_{C_3H_8O_3} = 30.2$ g $\qquad m_{water} = 150$ g

$$\begin{aligned}\Delta T_b &= K_b\, m \\ &= K_b \frac{\text{mol glycerol}}{\text{kg water}} \\ &= (0.515\ ^\circ\text{C}/m)\left(\frac{\frac{30.2}{92.1}\ \text{mol } C_3H_8O_3}{0.150\ \text{kg water}}\right) \\ &= 1.13^\circ\text{C}\end{aligned}$$

$$T_b = T_b^0 + \Delta T_b = 101.13^\circ\text{C}$$

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005 10.0 points

For the system

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

at equilibrium, the addition of $H_2(g)$ would cause (according to LeChatelier's principle)

1. only more $H_2O(g)$ to form.

2. only more $CO_2(g)$ to form.

3. more $H_2O(g)$ and $CO(g)$ to form. **correct**

4. no change in amounts of products or reactants.

5. only more $CO(g)$ to form.

Explanation:
LeChatelier's Principle states that if a change in conditions occurs to a system at equilibrium, the system responds to relieve the stress and reach a new state of equilibrium. $H_2(g)$ is the stress, so the reaction moves to the right to relieve the stress, forming more H_2O and CO.

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006 10.0 points

$K_c = 2.6 \times 10^8$ at 825 K for the reaction

$$2\,H_2(g) + S_2(g) \rightleftharpoons 2\,H_2S(g)$$

The equilibrium concentration of H_2 is 0.0020 M and that of S_2 is 0.0010 M. What is the equilibrium concentration of H_2S?

1. 0.10 M

2. 1.02 M **correct**

3. 0.0010 M

4. 10 M

Explanation:
$K_c = 2.6 \times 10^8 \qquad [H_2]_{eq} = 0.0020$ M
$[S_2]_{eq} = 0.0010$ M

$$2\,H_2(g) + S_2 \rightleftharpoons 2\,H_2S$$

$$\begin{aligned}K_c &= \frac{[H_2S]^2}{[H_2]^2\,[S_2]} \\ [H_2S] &= \sqrt{K_c\,[H_2]^2\,[S_2]} \\ &= \sqrt{(2.6 \times 10^8)\,(0.0020\ \text{M})^2\,(0.0010\ \text{M})} \\ &= 1.0\ \text{M}\end{aligned}$$

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007 10.0 points

Write the equilibrium expression for the following reaction:

$$2\ Fe(s) + \frac{3}{2}\ O_2(g) \longleftrightarrow Fe_2O_3(s)$$

1. $K = \dfrac{1}{P_{O_2}}$

2. $K = \dfrac{P_{Fe}^2}{{P_{O_2}}^{3/2} \cdot P_{Fe_2O_3}}$

3. $K = \dfrac{1}{P_{O_2}^{3/2}}$ **correct**

4. $K = \dfrac{P_{Fe}}{P_{O_2} \cdot P_{Fe_2O_3}}$

Explanation:

Set up K, products in the numerator, reactants in the denominator, all raised to respective stoichiometric coefficients.

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008 10.0 points

Consider the reaction:

$2\,HI(g) \leftrightarrow H_2(g) + I_2(g)$

If we start out with pure HI and the equilibrium hydrogen gas concentration is 0.233 M at 730 K and at this temperature Kc = 0.12, what is the correct expression for the equilibrium concentration of HI(g)?

1. $[HI] = (0.233 \cdot 0.233 \cdot 0.12)^{1/2}$

2. $[HI] = \left(\dfrac{0.233 \cdot 0.233}{0.12}\right)^{1/2}$ **correct**

3. $[HI] = (0.233 \cdot 0.233 \cdot 0.12)$

4. $[HI] = \left(\dfrac{0.233}{0.12}\right)^{1/2}$

5. $[HI] = \left(\dfrac{0.233 \cdot 0.233}{0.12}\right)$

Explanation:

Since we started from pure HI, the equilibrium concentrations of hydrogen and iodine gas must be equal.

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009 10.0 points

Consider the reaction,

$$A(aq) + B(aq) \longleftrightarrow C(aq)$$

The equilibrium constant, K, is 2. If the concentrations of A, B and C are 2 M, 2 M and 10 M, respectively, which of the following would occur?

1. the reaction would move left **correct**

2. nothing would occur

3. the reaction would move right

4. not enough information

Explanation:

$$Q = \frac{[C]}{[A] \cdot [B]} = \frac{10}{2 \cdot 2} = 2.5$$

Since $Q > K$, the reaction would move right.

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010 10.0 points

An acetic acid solution is allowed to come to equilibrium:

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

If some silver ion (Ag^+) is then added to the solution, solid silver acetate (CH_3COOAg) is formed.

The resulting amount of undissociated acetic acid (CH_3COOH) in the solution would be

1. unchanged from that in the original solution.

2. higher than that in the original solution.

3. zero.

4. lower than that in the original solution. **correct**

Explanation:

Precipitating out CH_3COOAg removes CH_3COO^- from the equilibrium system and shifts the equilibrium to the right, dissociating more CH_3COOH to replace CH_3COO^-.

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011 10.0 points

Consider the reaction

$$Ni(CO)_4(g) \rightarrow Ni(s) + 4\,CO(g)\,.$$

If the initial concentration of $Ni(CO)_4(g)$ is 1.0 M, and x is the equilibrium concentration of CO(g), what is the correct equilibrium relation?

1. $K_c = \dfrac{x^5}{1.0 - \dfrac{x}{4}}$

2. $K_c = \dfrac{x}{1.0 - \dfrac{x}{4}}$

3. $K_c = \dfrac{x^4}{1.0 - 4x}$

4. $K_c = \dfrac{4\,x}{1.0 - 4x}$

5. $K_c = \dfrac{x^4}{1.0 - \dfrac{x}{4}}$ **correct**

Explanation:

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012 10.0 points

Which of the following equilibrium reactions is NOT affected by changes in pressure?

1. $H_2(g) + Br_2(\ell) \rightarrow 2\,HBr(g)$

2. $H_2(g) + I_2(s) \rightarrow 2\,HI(g)$

3. $2\,CO_2(g) \rightarrow 2\,CO(g) + O_2(g)$

4. $2\,BrCl(g) \rightarrow Br_2(g) + Cl_2(g)$ **correct**

5. $2\,H_2O_2(\ell) \rightarrow 2\,H_2O(\ell) + O_2(g)$

Explanation:

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013 10.0 points

Consider the solutions

I) 1.0 M Na_2SO_4,
II) 1.0 M NaCl, and
III) 1.0 M sugar.

What answer gives the expected order of decreasing (highest, next, lowest) osmotic pressure?

1. II, III, I

2. III, I, II

3. II, I, III

4. All would have the same osmotic pressure.

5. III, II, I

6. I, II, III **correct**

Explanation:

The equation for osmotic pressure is $\pi = M\,R\,T$ where π is the osmotic pressure, M is the molarity, and R and T are the same for the ideal gas law. If molarity increases then the osmotic pressure increases (they are directly proportional). Since this is a colligitive property, it is the number of moles of the particles that is important. Since sugar does not ionize, there is only one mole of particles present for each mole of sugar dissolved, so its effective molarity is 1.0 M. Each NaCl ionizes to give two ions so the effective molarity is $2(1.0) = 2.0$ M. And lastly Na_2SO_4; this also ionizes and gives three ions, so its effective molarity is $3(1.0) = 3.0$ M.

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014 10.0 points

A container holds a mixture of acetone and water at 40 °C. If χ_{acet}, the mole fraction of acetone, is 0.1, what is the total vapor pressure? (The equilibrium vapor pressures for pure acetone and pure water at 40 °C are roughly 400 torr and 50 torr respectively.)

1. 50 torr

2. 85 torr **correct**

3. 365 torr

4. 40 torr

5. 400 torr

Explanation:

$$\begin{aligned} P &= P_{H_2O} + P_{acet} \\ &= \chi_{H_2O} P^\circ_{H_2O} + \chi_{acet} P^\circ_{acet} \\ &= (1 - \chi_{acet}) P^\circ_{H_2O} + \chi_{acet} P^\circ_{acet} \\ &= (0.9)(50) + (0.1)(400) \\ &= 85 \end{aligned}$$

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015 10.0 points

Which of the solutions below will have the greater boiling point and what will it be? $K_b = 0.512$ °C/m for water.

I) 135 g of glucose ($C_6H_{12}O_6$) dissolved in 0.5 kg water
II) 35 g of NaCl dissolved in 0.5 kg of water

1. Solution I with a boiling point of

118.4 °C

2. Solution I with a boiling point of 100.8 °C

3. Solution II with a boiling point of 101.2 °C **correct**

4. Solution II with a boiling point of 100.6 °C

Explanation:
First calculate the molality of each solution, which is mol solute per kg solvent. To do this, you will need to convert from mass to mols, using molar mass. Remember also that $i = 2$ for NaCl and $i = 1$ for glucose. Using $\Delta T = imK_b$ you will find that $\Delta T = 0.768$ °C for the glucose solution and 1.227 for the salt solution, which means the boiling point of the salt solution will be 101.2 °C.

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016 10.0 points

How much heat is required to vaporize 50.0 g of water if the initial temperature of the water is 25.0°C and the water is heated to its boiling point where it is converted to steam? The specific heat capacity of water is 4.18 $\mathrm{J \cdot (^\circ C)^{-1} \cdot g^{-1}}$ and the standard enthalpy of vaporization of water at its boiling point is 40.7 $\mathrm{kJ \cdot mol^{-1}}$.

1. 23.5 kJ

2. 64.2 kJ

3. 40.7 kJ

4. 169 kJ

5. 129 kJ **correct**

Explanation:
$m = 50$ g $\qquad T_\mathrm{i} = 25^\circ$C
$T_\mathrm{f} = 100^\circ$C $\qquad C = 4.18$ J/g/°C
$\Delta H_\mathrm{vap} = 40.7$ kJ/mol

$$\begin{aligned} H &= m\,C\,\Delta T + \frac{m}{\mathrm{MM}}\,\Delta H_\mathrm{vap} \\ &= (50\text{ g})\,(4.18\text{ J/g/}^\circ\mathrm{C}) \\ &\quad \times (100 - 25)^\circ\mathrm{C}\,\frac{1\text{ kJ}}{1000\text{ J}} \\ &\quad + \frac{50\text{ g}}{18\text{ g/mol}}\,(40.7\text{ kJ/mol}) \\ &= 128.731\text{ kJ} \end{aligned}$$

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017 10.0 points

For an endothermic dissolution process, as temperature increases, solubility

1. increases. **correct**

2. decreases.

3. stays the same.

Explanation:
Consider an endothermic process:
solid + heat → dissolved products
As heat is added, equilibrium will shift towards a higher concentration of dissolved products.

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018 10.0 points

Which of the following gases are more soluble in water when their partial pressure above the solution is increased?

$$\mathrm{HI, SO_3, NH_3, O_2, NO_2, HF, Cl_2}$$

1. $\mathrm{Cl_2, NO_2, SO_3, HI}$

2. all of them **correct**

3. $\mathrm{HI, NH_3}$

4. $\mathrm{SO_3, NO_2, HI}$

5. $\mathrm{NO_2, O_2, HI}$

6. $\mathrm{NO_2, SO_3}$

Explanation:
Henry's Law states that the solubility of gases increase as their partial pressure above the solvent increases.