This print-out should have 20 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points

Which of the following is not true about the catalyst responsible for the hole in the ozone layer?

1. Sunlight facilitates the formation of the catalyst.

2. The catalyst's source is often a chlorofluorocarbon.

3. It is a heterogeneous catalyst. **correct**

4. It is a free radical.

5. Ozone is converted to O_2 in the catalyzed reaction.

Explanation:

002 10.0 points

Which of the following can increase the rate of reaction by increasing the rate constant k?

I. raising the temperature
II. decreasing the volume
III. adding a catalyst
IV. increasing the concentration

1. II only

2. I only

3. I, II, and III only

4. III and IV only

5. I and III only **correct**

Explanation:

003 10.0 points

If $k = 2.7 \times 10^{-6}\ \mathrm{M^{-1}s^{-1}}$ for the reaction

$$\mathrm{A} \rightarrow \mathrm{B}$$

which of the following is the correct rate law?

1. rate $= k\,[\mathrm{A}]^0\,[\mathrm{B}]^{-1}$

2. rate $= k\,[\mathrm{A}]^0$

3. rate $= k\,[\mathrm{A}]^2$ **correct**

4. rate $= k\,[\mathrm{A}]^2\,[\mathrm{B}]^{-1}$

5. rate $= k\,[\mathrm{A}]^1$

Explanation:

004 10.0 points

Calculate the density of camphor ($C_{10}H_{16}O$) at 80°C and 12 Torr.

1. $0.083\ \mathrm{g \cdot L^{-1}}$ **correct**

2. $6.8 \times 10^{-3}\ \mathrm{g \cdot L^{-1}}$

3. $0.37\ \mathrm{g \cdot L^{-1}}$

4. $0.62\ \mathrm{g \cdot L^{-1}}$

5. $8.2 \times 10^{-4}\ \mathrm{g \cdot L^{-1}}$

Explanation:

$T = 80^\circ\mathrm{C} + 273.15 = 353.15\ \mathrm{K}$

$$P = (12\ \mathrm{Torr})\,\frac{1\ \mathrm{atm}}{760\ \mathrm{Torr}} = 0.0157895\ \mathrm{atm}$$

The ideal gas law is

$$P\,V = n\,R\,T$$
$$\frac{n}{V} = \frac{P}{RT}$$

with unit of measure mol/L on each side. Multiplying each by molar mass (MM) gives

$$\frac{n}{V} \cdot \mathrm{MM} = \frac{P}{RT} \cdot \mathrm{MM}\,,$$

which now has units of g/L (= density). Thus

$$\begin{aligned}\rho &= \frac{P}{RT} \cdot \mathrm{MM} \\ &= \frac{0.0157895\ \mathrm{atm}}{(0.08206\ \mathrm{L \cdot atm/mol/K})\,(353.15\ \mathrm{K})} \\ &\quad \times (152.233\ \mathrm{g/mol}) \\ &= 0.0829444\ \mathrm{g/L}\end{aligned}$$

005 10.0 points

Lithium metal reacts with nitrogen gas to produce lithium nitride. What volume of nitrogen gas at 2 atm and 175°C is required to produce 75.0 g of lithium nitride?

1. 39.6 L

2. 79.2 L

3. 19.8 L **correct**

4. 119 L

5. 7.73 L

Explanation:

$P = 2$ atm $\qquad m = 75$ g

$T = 175^\circ\text{C} + 273.15 = 448.15$ K

The balanced equation is

$$6\,\text{Li} + \text{N}_2 \rightarrow 2\,\text{Li}_3\text{N}$$

$\text{FW}_{\text{Li}_3\text{N}} = 34.8297$ g/mol

$$n_{\text{Li}_3\text{N}} = \frac{75\text{ g}}{34.8297\text{ g/mol}} = 2.15333\text{ mol Li}_3\text{N}$$

$$n_{\text{N}_2} = \frac{2.15333\text{ mol Li}_3\text{N}}{2\text{ mol Li}_3\text{N/mol N}_2} = 1.07667\text{ mol N}_2$$

$$\begin{aligned} V &= \frac{n_{\text{N}_2} R T}{P} \\ &= (1.07667\text{ mol N}_2)\left(0.08206\,\frac{\text{L}\cdot\text{atm}}{\text{K}\cdot\text{mol}}\right) \\ &\quad \times \frac{(448.15\text{ K})}{2\text{ atm}} \\ &= 19.7973\text{ L N}_2 \end{aligned}$$

006 10.0 points

Calculate the ratio of the rate of effusion of CO_2 to that of He (at the same temperatures).

1. 1 : 11

2. $1 : 11^2$

3. $\sqrt{11} : 1$

4. $11^2 : 1$

5. 1 : 1

6. 11 : 1

7. $1 : \sqrt{11}$ **correct**

Explanation:

$$\frac{\text{Eff}_{\text{CO}_2}}{\text{Eff}_{\text{He}}} = \frac{\sqrt{\text{MW}_{\text{HC}}}}{\sqrt{\text{MW}_{\text{CO}_2}}} = \sqrt{\frac{4}{44}} = \sqrt{\frac{1}{11}}$$

007 10.0 points

Rank the gases H_2, CH_3F, N_2, CF_4, HF from left to right in terms of the increased non-ideality that results from a reduction in the effective pressure of the gas due to intermolecular forces.

1. H_2, N_2, CF_4, CH_3F, HF **correct**

2. CF_4, CH_3F, N_2, HF, H_2

3. H_2, N_2, HF, CH_3F, CF_4

4. H_2, CH_3F, N_2, CF_4, HF

5. H_2, HF, N_2, CH_3F, CF_4

6. HF, CH_3F, CF_4, N_2, H_2

Explanation:

The stronger the intermolecular forces present, the greater the non-ideality.

Induced Dipole	H_2	smallest, most ideal
	N_2	↓
	CF_4	largest
Dipole – dipole	CH_3F	
Hydrogen Bonding	HF	least ideal

008 10.0 points

The molar volume of a gas at STP is

1. 22.4 liters. **correct**

2. 12.4 gallons.

3. 12.4 liters.

4. 6.02×10^{23} liters.

Explanation:
Avogadro's Law states that at the same temperature and pressure, equal volumes of all gases contain the same number of molecules. The standard molar volume of an ideal gas is taken to be 22.414 liters per mol at STP.

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009 10.0 points

All of the following statements, except one, are important postulates of the kinetic-molecular theory of ideal gases. Which one is not a part of this kinetic molecular theory?

1. The average kinetic energy of the molecules is inversely proportional to the absolute temperature. **correct**

2. The time during which a collision between two molecules occurs is negligibly short compared to the time between collisions.

3. There are no attractive nor repulsive forces between the individual molecules.

4. The volume of the molecules of a gas is very small compared to the total volume in which the gas is contained.

5. Gases consist of large numbers of particles in rapid random motion.

Explanation:
The average kinetic energy of gas molecules is DIRECTLY (not indirectly) proportional to the absolute temperature. As temperature increases, so does kinetic energy.

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010 10.0 points

Which of the following statements is true about the speeds of molecules in a gas sample?

1. As the temperature is raised the fraction of molecules with high speeds decreases.

2. As the temperature is raised the fraction of molecules with high speeds increases. **correct**

3. The fraction of molecules having very low speeds is high.

4. As the temperature is raised the fraction of molecules with low speeds increases.

5. As the temperature is raised the fraction of molecules with a given speed remains unchanged.

Explanation:
By kinetic molecular theory,
Average molecular speed is

$$\overline{U} \propto \sqrt{\frac{T}{\mathrm{MW}}} \propto \sqrt{T}$$

for a given molecule, so as T increases, so does the average molecular speed.

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011 10.0 points

In an improved version of the gas law, V is replaced by $(V - n\,b)$. Which of the following would you predict has the largest b?

1. He

2. Ar

3. Kr

4. Xe **correct**

5. Ne

Explanation:
Xe is the largest of the molecules given, and therefore has stronger and longer lasting lasting London forces.

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012 10.0 points

If we increase the volume of a gaseous system by a factor of 3 and raise the temperature by a factor of 6, then the pressure of the system will (increase/decrease) by a factor of (2/18):

1. increase, 2 **correct**

2. increase, 18

3. decrease, 2

4. decrease, 18

Explanation:

Tripling the volume will decrease the pressure by a factor of 3 and sextupling the temperature will increase the pressure by a factor of 6, resulting a double the original pressure.

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013 10.0 points

Which of the following statements is/are true?

I) At a given temperature, larger molecules have greater average kinetic energy than smaller molecules.

II) As the temperature of a gaseous system rises, the gas molecules' average speed increases.

III) Gas molecules have an average rate of diffusion that is lower than their average velocity.

1. I, II

2. I only

3. II, III **correct**

4. I, II, III

5. II only

6. I, III

7. III only

Explanation:

At a given temperature, all gas molecules, regardless of their size, have the same average kinetic energy. The temperature of the system is directly proportional to the average kinetic energy of the molecules, and therefore their average velocity/speed as well. Because diffusion is net directional motion, not random motion, it occurs much more slowly than the gas molecules move.

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014 10.0 points

Consider the data below:

	[NO] M	$[CO_2]$ M	initial rate $M \cdot s^{-1}$
Exp 1	0.4	1.2	2.178×10^{-1}
Exp 2	0.8	2.4	8.572×10^{-1}
Exp 3	0.4	0.6	2.178×10^{-1}

Which of the following is a correct rate law for the reaction?

1. $k \cdot [CO_2]^2[NO]^{-1}$

2. $k \cdot [CO_2]^2$

3. $k \cdot [NO]^2$ **correct**

4. $k \cdot [NO]$

5. $k \cdot [NO] \cdot [CO_2]$

Explanation:

$$\frac{\text{rate}_1}{\text{rate}_3} = \left(\frac{[CO_2]_1}{[CO_2]_3}\right)^x$$

$$\frac{2.178 \times 10^{-1}}{2.178 \times 10^{-1}} = \left(\frac{1.2}{0.6}\right)^x$$

$$x = 0$$

$$\frac{\text{rate}_1}{\text{rate}_2} = \left(\frac{[NO]_1}{[NO]_2}\right)^y$$

$$\frac{2.178 \times 10^{-1}}{8.572 \times 10^{-1}} = \left(\frac{0.4}{0.8}\right)^y$$

$$y = 2$$

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015 10.0 points

A non-steroidal anti-inflammatory drug is metabolized with a first-order rate constant of 3.25 day^{-1}. What is the half-life for the metabolism reaction?

1. 1.63 day

2. 2.25 day

3. 0.213 day **correct**

4. 0.308 day

Explanation:

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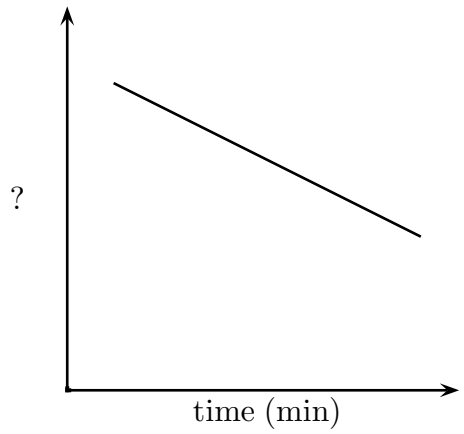
016 10.0 points

If the plot below were for a 1^{st} order reaction, what units belong on the y-axis?



1. Not enough information

2. [A] (M)

3. ln [A] **correct**

4. $\frac{1}{[A]}$ (M^{-1})

Explanation:
The y-axis would be in units of ln [A].

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017 10.0 points

In collision theory, temperature most impacts which of the following terms?

1. collision frequency **correct**

2. steric requirements

3. Collision theory has nothing to do with temperature.

4. activation energy

Explanation:
Collision frequency varies with the square root of the system's temperature (among several other factors).

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018 10.0 points

Consider the reaction mechanism below:

Step	Reaction
1	$C_2H_4 + BrF \longrightarrow C_2H_4F + Br$
2	$C_2H_4F + BrF \longrightarrow C_2H_4F_2 + Br$
3	$Br + Br \longrightarrow Br_2$
overall	$C_2H_4 + 2\,BrF \longrightarrow C_2H_4F_2 + Br_2$

What is the rate law if step 2 is the rate-determining step?

1. rate $= k \cdot [C_2H_4] \cdot [BrF]^2$

2. rate $= k \cdot [C_2H_4] \cdot [BrF]^2 \cdot [C_2H_4F_2]^{-1}$

3. rate $= k \cdot [C_2H_4] \cdot [BrF]$

4. rate $= k \cdot [C_2H_4] \cdot [BrF]^2 \cdot [Br]^{-1}$ **correct**

5. rate $= k \cdot [C_2H_4] \cdot [BrF] \cdot [Br]^{-1}$

Explanation:
Canceling intermediates reveals that only the reactants influence the rate and do so according to the stoichiometry of the overall equation.

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019 10.0 points

Consider the reaction mechanism below:

Step	Reaction
1	$Cl_2 + Pt \longrightarrow 2\,Cl + Pt$
2	$Cl + CO + Pt \longrightarrow ClCO + Pt$
3	$Cl + ClCO \longrightarrow Cl_2CO$
overall	$Cl_2 + CO \longrightarrow Cl_2CO$

Which species is/are intermediates?

1. Pt

2. Cl, ClCO **correct**

3. Pt, ClCO

4. Cl

5. Pt, Cl

6. ClCO

Explanation:

Both Cl and ClO are produced in early steps and stiochiometrically consumed in subsequent steps and neither appear in the overall reaction.

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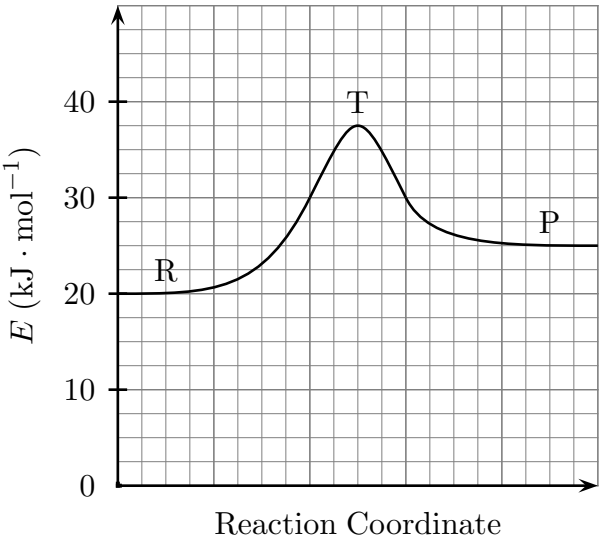
020 10.0 points

What is the activation energy for the forward reaction in the diagram below?



1. 17.5 kJ · mol^{-1} **correct**

2. 5.0 kJ · mol^{-1}

3. 20.0 kJ · mol^{-1}

4. 12.5 kJ · mol^{-1}

5. 25.0 kJ · mol^{-1}

6. 37.5 kJ · mol^{-1}

Explanation:

The difference in energies between the transition state and the ground state reactants is 17.5 kJ · mol^{-1} .