1. (Multiple choice) Which of the following substances would you predict to have the highest boiling point?

A. CH₄  
B. Cl₂  
C. Kr  
D. CH₃Cl  
E. N₂

*Dipole-dipole (and dispersion) interactions: others just dispersion.*

2. (Multiple choice) Helium atoms do not combine to form He₂ molecules, yet He atoms do attract one another weakly through

A. dipole-dipole forces  
B. ion-dipole forces  
C. dispersion forces  
D. dipole-induced dipole forces  
E. hydrogen bonding

3. (Multiple choice) Which one of the following substances should exhibit hydrogen bonding in the liquid state?

A. PH₃  
B. He  
C. H₂S  
D. CH₄  
E. CH₃OH

*Hydrogens bonded to N,F,O can be H-bond donors; N,F,O can be acceptors.*
4. For the following reaction, $\Delta [C_6H_{14}] / \Delta t$ was found to be $-6.2 \times 10^{-3}$ M/s.

$$C_6H_{14(g)} \rightarrow C_6H_6(g) + 4H_2(g)$$

Determine $\Delta [H_2] / \Delta t$ for this reaction at the same time.

$$2.5 \times 10^{-2} \text{ M/s}$$

It's increasing (therefore positive) at 4x the rate.

5. The reaction $2A + B \rightarrow C$ was found to have the rate law: rate = $k[A]^2[B]$.

Predict by what factor the rate of reaction will increase when the concentration of A is doubled and the concentration of B is tripled.

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6. The reaction $A + 2B \rightarrow C$ has the rate law: rate = $k[A][B]^3$. What are the units of the rate constant $k$?

$1/(M^3s)$ or $M^{-3}s^{-1}$

Remember, the units on the right have to leave you with the same units (M/s) that are on the left.
7. (Multiple choice) For the overall chemical reaction shown below, which one of the following statements can be rightly assumed?

\[ 2\text{H}_2\text{S}(g) + \text{O}_2(g) \rightarrow 2\text{S}(s) + 2\text{H}_2\text{O}(l) \]

A. The reaction is third-order overall.
B. The reaction is second-order overall.
C. The rate law is: \( \text{rate} = k[\text{H}_2\text{S}]^2[\text{O}_2] \).
D. The rate law is: \( \text{rate} = k[\text{H}_2\text{S}][\text{O}_2] \).
E. There is not enough information to predict the rate law.

*The order does not necessarily have anything to do with the coefficients in the chemical equation.*

8. The following initial rate data apply to the reaction

\[ \text{F}_2(g) + 2\text{Cl}_2\text{O}(g) \rightarrow 2\text{FClO}_2(g) + \text{Cl}_2(g) \]

<table>
<thead>
<tr>
<th>Expt #</th>
<th><a href="M">\text{F}_2</a></th>
<th><a href="M">\text{Cl}_2\text{O}</a></th>
<th>Initial rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.050</td>
<td>0.010</td>
<td>5.0 \times 10^{-4}</td>
</tr>
<tr>
<td>2</td>
<td>0.050</td>
<td>0.040</td>
<td>2.0 \times 10^{-3}</td>
</tr>
<tr>
<td>3</td>
<td>0.100</td>
<td>0.010</td>
<td>1.0 \times 10^{-3}</td>
</tr>
</tbody>
</table>

a. What is the overall order of the reaction?

2

*First order in both*

b. What is the value of the rate constant \( k \) for this reaction (including units)?

1.0 M\(^{-1}\)s\(^{-1}\)

c. What would be the initial rate if this reaction were run at [\text{F}_2] = 0.030 M and [\text{Cl}_2\text{O}] = 0.021 M?

6.3 \times 10^{-4} M/s
9. If the activation energy for a biological reaction is 50.0 kJ/mol, by what factor (how many times) will the rate of this reaction increase when body temperature increases from 37°C (normal) to 40°C (fever)? (Given equation 14.12 from page 459 and R = 8.314 J/(K*mol))

\[ \text{ratio of } k_1/k_2 \]

find the ratio of \( k_1/k_2 \)

(I’d probably give you the equation above 14.12)

10. Write an equation for the equilibrium constant for the following reaction in terms of concentrations of reactants and products.

\[
2\text{CCl}_4(g) + \text{O}_2(g) \rightarrow 2\text{COCl}_2(g) + 2\text{Cl}_2(g)
\]

\[ K_c = [\text{COCl}_2]^2[\text{Cl}_2]^2/([\text{CCl}_4]^2[\text{O}_2]) \]

11. An equilibrium mixture for the reaction \( 2\text{H}_2\text{S}_g \leftrightarrow 2\text{H}_2(g) + \text{S}_2(g) \) was found to contain 1.0 mol \( \text{H}_2\text{S} \), 4.0 mol \( \text{H}_2 \), and 0.80 mol \( \text{S}_2 \) in a 4.0 L vessel at 457°C. Calculate the equilibrium constant, \( K_c \), for this reaction.

\[ K_c = 3.2 \]

Looking for \( K_c \), so you don’t need to change moles to pressures

Need equilibrium concentrations: #mol/L
12. (Multiple choice) At 700 K, the reaction \(2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{SO}_3(\text{g})\) has the equilibrium constant \(K_c = 4.3 \times 10^6\), and the following concentrations are present: \([\text{SO}_2] = 0.10 \text{ M; } [\text{SO}_3] = 10.0 \text{ M; } [\text{O}_2] = 0.010 \text{ M}\). Is the mixture at equilibrium? If not, in which direction will the reaction proceed to reach equilibrium?

A. Yes, the mixture is at equilibrium.
B. No, left to right.
C. No, right to left.
D. There is not enough information to be able to predict the direction.

You should find that \(Q < K\).

Either memorize the rules for \(Q = K\), \(Q < K\), \(Q > K\) or think about what the numerators are. If \(Q < K\), the numerator will have to get bigger in order to achieve equilibrium: \([\text{SO}_3]\) is too small…the reaction has to form products and will go left to right.

13. 5.0 mol of ammonia (NH\(_3\)) are introduced into a 5.0 L reaction vessel where it partially dissociates according to the following reaction: \(2\text{NH}_3 \leftrightarrow 3\text{H}_2(\text{g}) + \text{N}_2(\text{g})\). At equilibrium, 1.0 mol of ammonia remains. Calculate \(K_c\) for the reaction.

\[K_c = 17.3\]

Use Initial/Change/Equilibrium. You should find that ‘x’ is 0.4 M. So at equilibrium \([\text{NH}_3]=0.2\text{ M; } [\text{H}_2]=1.2\text{ M; } [\text{N}_2]=0.4\text{ M}].\]
14. Hydrogen iodide decomposes according to the equation:

\[ 2\text{HI(g)} \leftrightarrow \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \quad K_c = 0.0156 \text{ at } 400^\circ \text{C}. \]

A 0.660 mol sample of HI was injected into a 2.0 L reaction vessel held at 400°C. Calculate the concentrations of H₂ and HI at equilibrium.

\[ [\text{H}_2] = 0.033 \text{ M}, [\text{HI}] = 0.264 \text{ M} \]