

## Recitation Worksheet Three: Exam One Review

Name:

Key

MyID:

### Textbook:

Chemistry & Chemical Reactivity

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### Instructions:

- This recitation worksheet is a review for Exam One.
- Exam coverage: Ch. 5.3, 11, 12, 14.1-14.4
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- The **recitation session during the exam week (September 9-12) is still mandatory**. Your attendance will be recorded.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. Pick the **most significant** IMF/bond for the following compounds (or compounds pair).

- A. dipole-dipole forces  
 B. ion-induced dipole forces  
 C. hydrogen bond  
 D. ion-dipole forces  
 E. dispersion forces  
 F. ionic bond

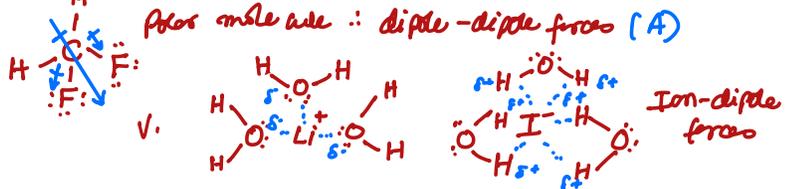
- I. LiI F
- II. CH<sub>3</sub>OH C
- III. CH<sub>3</sub>CH<sub>3</sub> E
- IV. CH<sub>2</sub>F<sub>2</sub> A
- V. between LiI and H<sub>2</sub>O D

I. Li<sup>+</sup> = metal + I<sup>-</sup> = non-metal = ionic compound = ionic bond (F)

II. H-C-O-H hydrogen is covalently bonded to oxygen ∴ hydrogen bond (C)

III. H-C-C-H carbon-hydrogen bonds are non-polar ∴ dispersion forces (E)

IV. Polar molecule ∴ dipole-dipole forces (A)



2. Which of the following statements is **not** consistent with the properties of a molecular solid?

- A A. a compound that conducts electricity when molten  
 B. a low melting solid  
 C. a solid formed by the combination of two nonmetallic elements  
 D. a solid that is a nonconductor of electricity

the molecules in a crystalline molecular solid are held by intermolecular forces such as: dispersion forces, dipole-dipole forces, or hydrogen bonding

- (A) molecular solids have low melting points & do not conduct electricity
- (B) True due to weak intermolecular forces
- (C) true
- (D) true

3. Ethanol (C<sub>2</sub>H<sub>5</sub>OH) has a normal boiling point of 78.3 °C and, ΔH<sub>vap</sub> = 39.3 kJ/mol. What is the vapor pressure of ethanol at 50.0 °C? Keep 3 significant figures.

**234** Torr

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$P_1 = 760 \text{ Torr}$   
 $T_1 = 78.3 + 273.15 = 351.45 \text{ K}$   
 $P_2 = ?$   
 $T_2 = 50.0 + 273.15 = 323.15 \text{ K}$

①  $\ln\left(\frac{P_2}{760}\right) = \frac{39.3 \text{ kJ/mol}}{8.314 \times 10^{-3} \text{ kJ/mol}\cdot\text{K}} \left(\frac{1}{351.45} - \frac{1}{323.15}\right)$

②  $\ln\left(\frac{P_2}{760}\right) = -1.17788057$

③ Take the inverse of ln e<sup>x</sup>  
 $\therefore \frac{P_2}{760} = e^{-1.17788057}$   
 $\therefore \frac{P_2}{760} = 0.307930685$   
 $\therefore P_2 = 234.0273206 \approx 234 \text{ Torr}$

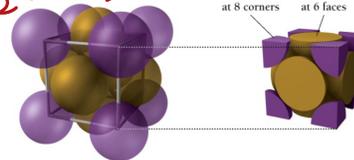
4. How many atoms are in one face-centered cubic unit cell of a metal?

**D**  
 A. 1  
 B. 2  
 C. 3  
 D. 4

In a face-centered cubic unit cell there are 8 atoms (1/8 atom) on each corner & 1 atom on each face (1/2 atom)

$$\text{Atoms/unit} = \left(\frac{1}{8} \times 8\right) + \left(\frac{1}{2} \times 6\right) = 4$$

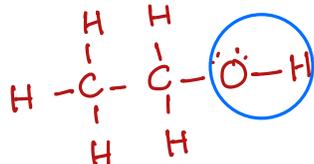
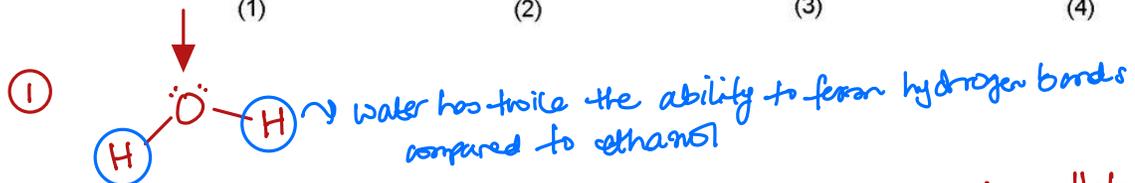
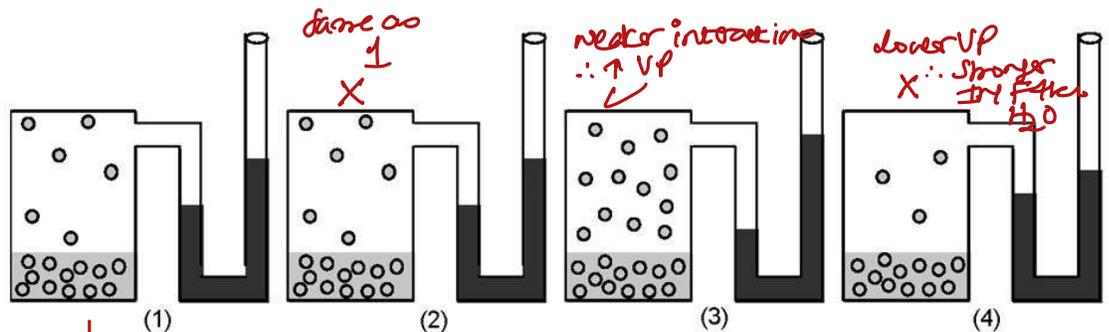
$\therefore \left(8 \times \frac{1}{8}\right) + \left(6 \times \frac{1}{2}\right) = 4 \text{ atoms}$



5. If figure (1) represents the vapor pressure of water at 25 °C, which figure represents the vapor pressure of ethanol, CH<sub>3</sub>CH<sub>2</sub>OH at 25 °C?

**B**  
 A. figure (2)  
 B. figure (3)  
 C. figure (4)

\* ↑ IMF strength = ↓ VP  
 ↓ IMF strength = ↑ VP



② If ethanol has only one site to form H-bonding compared to water ∴ the vapor pressure will increase & you are expected to see more molecules in the vapor phase

6. Which of the following statements is false?

E

- A. Vapor pressure occurs in a closed container when the rate at which molecules are leaving the liquid phase and entering the gas phases is equal to the rate at which gas molecules are returning to the liquid phase *True - this describes dynamic equilibrium*
- B. Evaporation can occur below the boiling point because even then some molecules have enough kinetic energy to escape *True*
- C. Evaporation decreases at low temperature because then a lower percentage of molecules have enough energy to escape *True*
- D. At a given temperature molecules in the gas phase have more energy than molecules in the liquid phase *True (kinetic molecular theory)*
- E. The stronger the noncovalent binding forces, the ~~faster~~ *slower* a liquid will evaporate

↓  
intermolecular forces

7. How much heat (in kJ) is absorbed when 475 g of water initially at  $-23.5^\circ\text{C}$  is heated to  $218^\circ\text{C}$ ?

$\Delta H_{\text{fus}}$  of water = 334 J/g  
 $\Delta H_{\text{vap}}$  of water = 2257 J/g  
 C of ice = 2.09 J/g $\cdot^\circ\text{C}$   
 C of water = 4.18 J/g $\cdot^\circ\text{C}$   
 C of steam = 2.09 J/g $\cdot^\circ\text{C}$

$1.57 \times 10^3$  kJ

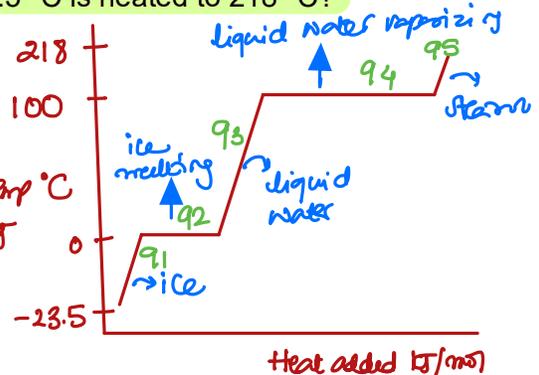
①  $q_1 = m \times C_{\text{ice}} \times \Delta T$   
 $= 475\text{g} \times 2.09\text{ J/g}\cdot^\circ\text{C} \times (0.0 - (-23.5))^\circ\text{C}$   
 $= 23329.625\text{ J}$   
 $= 23.329625\text{ kJ}$

②  $q_2 = m \times \Delta H_{\text{fus}}$   
 $= 475\text{g H}_2\text{O} \times 334\text{ J/g}$   
 $= 158650\text{ J} = 158.650\text{ kJ}$

③  $q_3 = m \times C_{\text{water}} \times \Delta T$   
 $= 475\text{g} \times 4.18\frac{\text{J}}{\text{g}\cdot^\circ\text{C}} \times (100.0 - 0.0)^\circ\text{C}$   
 $= 198550\text{ J} = 198.550\text{ kJ}$

④  $q_4 = m \times \Delta H_{\text{vap}}$   
 $= 475\text{g} \times 2257\text{ J/g} = 1072075\text{ J}$   
 $= 1072.075\text{ kJ}$

⑤  $q_5 = m \times C_{\text{steam}} \times \Delta T$   
 $= 475\text{g} \times 2.09\text{ J/g}\cdot^\circ\text{C} \times (218 - 100.0)^\circ\text{C}$   
 $= 117144.5\text{ J}$   
 $= 117.1445\text{ kJ}$



8. Which of these compounds has the largest lattice energy?

C

MgCO<sub>3</sub>      Na<sub>2</sub>CO<sub>3</sub>      Al<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>

- A. Na<sub>2</sub>CO<sub>3</sub> <sup>H 2-</sup>
- B. MgCO<sub>3</sub> <sup>H 2-</sup>
- C. Al<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub> <sup>3+ 2-</sup>
- D. They all have the same lattice energy.
- E. Not enough information is available to determine which is largest.

$\therefore q_{\text{total}} = q_1 + q_2 + q_3 + q_4 + q_5$   
 $= 1569.749125$   
 $\approx 1570\text{ kJ}$

Lattice energy depends on two factors

Ionic size

As ionic size decreases  
 $\therefore$  lattice energy increases

\* Note: ionic charge is more important

Ionic charge

As ionic charge increases,  
 lattice energy increases

$$\begin{array}{r}
 23.329625 \\
 158.650 \\
 198.550 \\
 1072.075 \\
 117.1445 \\
 \hline
 1569.749125 \\
 \approx 1570\text{ kJ} \\
 \text{or } 1.57 \times 10^3
 \end{array}$$

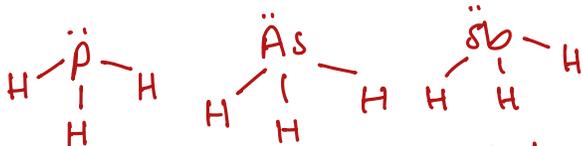
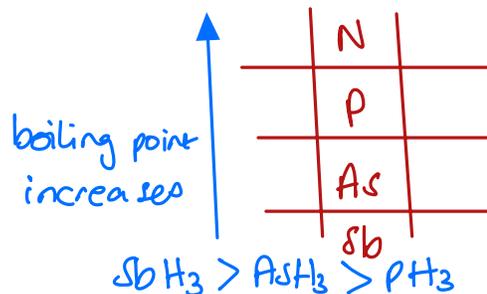


12. Predict the order in which boiling points of these hydrides decrease (highest boiling point first, lowest last):

PH<sub>3</sub>, AsH<sub>3</sub>, SbH<sub>3</sub>

C

- A. PH<sub>3</sub>, AsH<sub>3</sub>, SbH<sub>3</sub>
- B. AsH<sub>3</sub>, SbH<sub>3</sub>, PH<sub>3</sub>
- C. SbH<sub>3</sub>, AsH<sub>3</sub>, PH<sub>3</sub>
- D. PH<sub>3</sub>, SbH<sub>3</sub>, AsH<sub>3</sub>
- E. SbH<sub>3</sub>, PH<sub>3</sub>, AsH<sub>3</sub>



P, As, & Sb are all in group 5 & all have the same molecular geometry. The difference between these molecules is the central atom. As we go down a group the size of the atoms increases & the polarizability increases as the strength of dispersion forces & boiling point also increases

13. Which one of these substances does not exist in the indicated solid type?

C

- A. graphite – network
- B. Na – metallic
- C. SiO<sub>2</sub> (Quartz) – ~~molecular~~ network covalent
- D. NaCl – ionic
- E. diamond – network

14. A sample of octane in equilibrium with its vapor in a closed 1.0-L container has a vapor pressure of 50.0 torr at 45°C. The container's volume is increased to 2.0 L at constant temperature and the liquid/vapor equilibrium is reestablished. What is the vapor pressure?

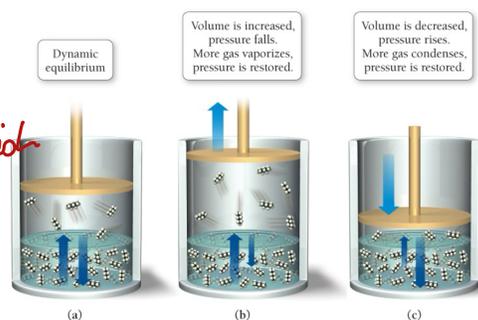
B

- A. > 50.0 torr
- B. 50.0 torr
- C. 25.0 torr
- D. The mass of the octane vapor is needed to calculate the vapor pressure.
- E. The external pressure is needed to calculate the vapor pressure.

\* Vapor pressure is not affected by changes in volume. Vapor pressure is an equilibrium system if disturbed it will try to reestablish its original state.

\* From the figure to the right as the volume increases the conc. of gases in the vapor phase decreases

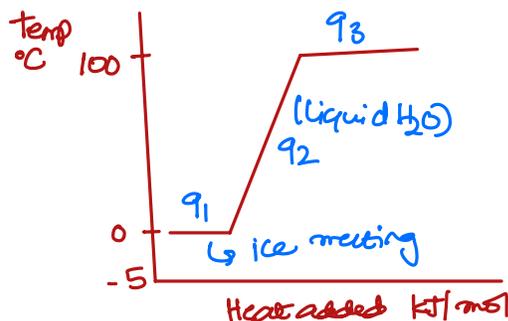
& molecules transfer from liquid to vapor phase (evaporate hence the big arrow) to reestablish equilibrium & vice versa



15. Assume 12,500 J of energy is added to 2.0 moles (36 grams) of H<sub>2</sub>O as an ice sample at 0°C. The molar heat of fusion is 6.02 kJ/mol. The specific heat of liquid water is 4.18 J/g °C. The specific heat of water vapor is 1.90 J/g °C. The molar heat of vaporization is 40.6 kJ/mol. The resulting sample contains which of these?

**C**

- A. water and water vapor
- B. ice and water
- C. only water
- D. only water vapor
- E. only ice



$$① q_1 = n \times \Delta H_{\text{fus}} = 2.0 \text{ mol} \times 6.02 \text{ kJ/mol} = 12.04 \text{ kJ} \times \frac{1000 \text{ J}}{1 \text{ kJ}} = 12040 \text{ J}$$

$$② q_2 = m \times C \times \Delta T = 36 \text{ g} \times 4.18 \text{ J/g}^\circ\text{C} \times (100 - 0)^\circ\text{C} = 15048 \text{ J}$$

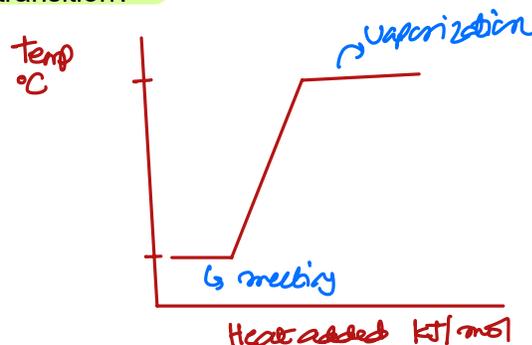
$$③ q_3 = n \times \Delta H_{\text{vap}} = 2.0 \text{ mol} \times 40.6 \text{ kJ/mol} = 81.2 \text{ kJ} \times \frac{1000 \text{ J}}{1 \text{ kJ}} = 81200 \text{ J}$$

From the calculations above we can see that the value of 12500 J above the value of  $q_1$  (12040 J)  $\therefore$  the sample must contain liquid H<sub>2</sub>O only

16. Which of these involves a change in temperature during the phase transition?

**E**

- A. condensation of water
- B. vaporization of ammonia
- C. fusion of ethanol
- D. all of the above
- E. none of the above



During phase transition, there is no change in temperature because all the heat from the previous step is expended breaking up all the intermolecular forces (phase transition is represented by the plateaus on the heat curve)

17. Closed system A consists of liquid acetone in equilibrium with its own vapor at 30°C. System B is like System A, except that the volume of liquid, the area of the liquid surface, and the volume of the vapor space above the liquid are all twice as large as System A, and the temperature is only 15°C. Identify the statement among the following that is false.

**D**

- A. Evaporation and condensation rates are equal in A
- B. Evaporation and condensation rates are equal in B
- C. Evaporation rate in A is greater than evaporation rate in B
- D. Vapor pressure in B is greater than vapor pressure in A
- E. Condensation rate in A is greater than condensation rate in B



Both contain acetone

\* Vapor pressure is not affected by surface area or volume of the closed container system as long as the liquids are the same

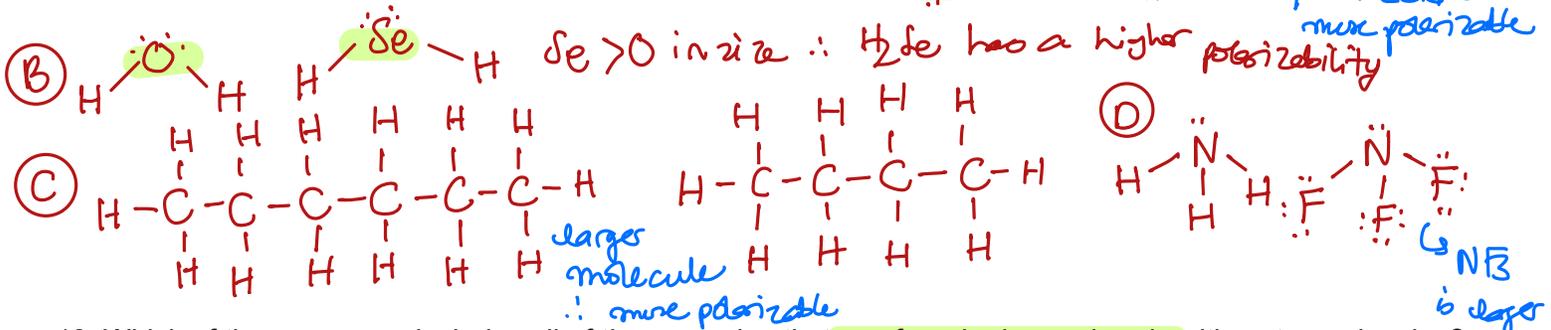
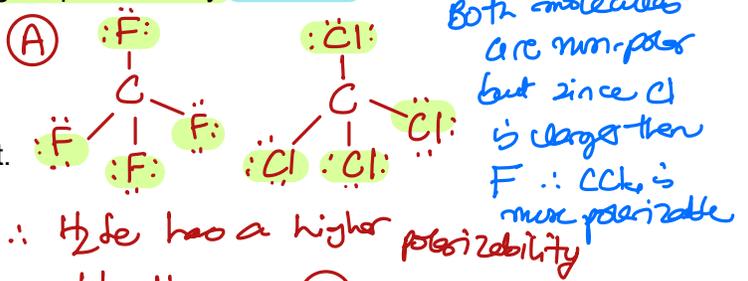
\* Vapor pressure is affected by temperature  $\uparrow$  temperature  $\uparrow$  vapor pressure

polarizability depends on the size of the molecule

18. Which of these pairs is arranged with the particle of higher polarizability listed first?

C

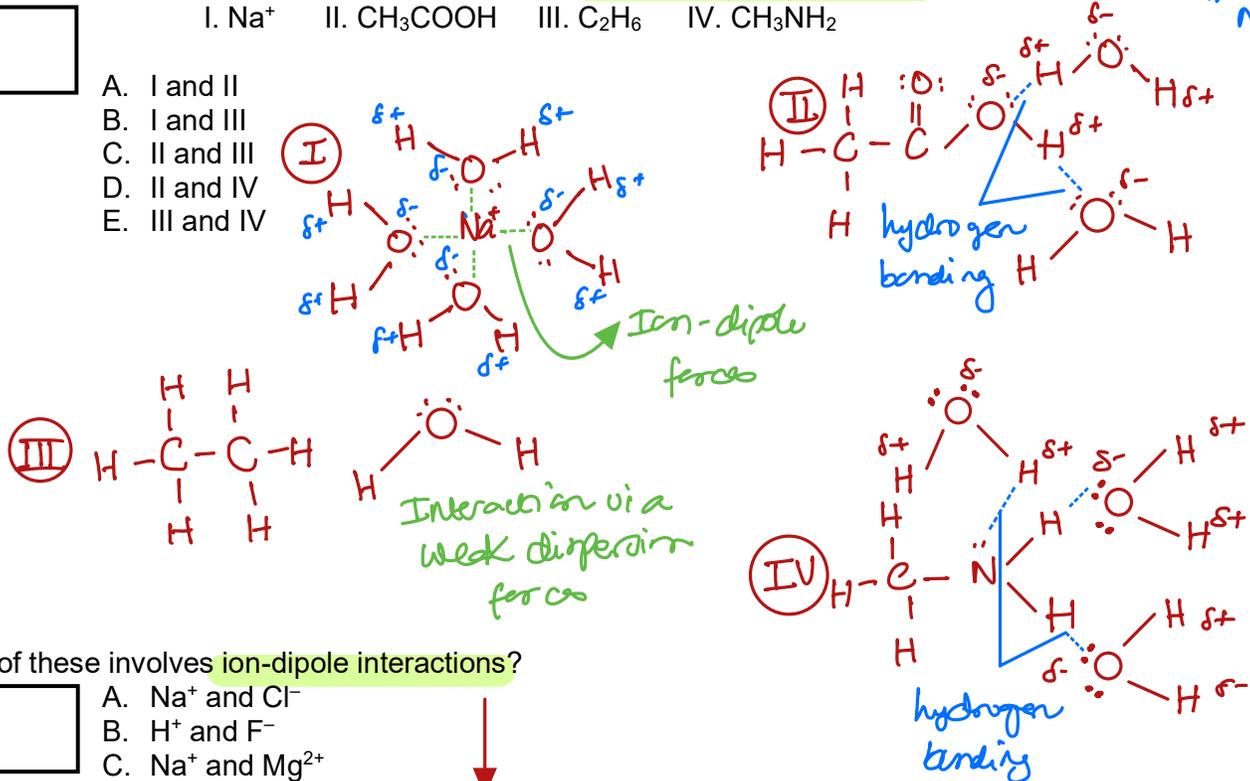
- A.  $CF_4, CCl_4$
- B.  $H_2O, H_2Se$
- C.  $C_6H_{14}, C_4H_{10}$
- D.  $NH_3, NF_3$
- E. None of these choices is correct.



19. Which of the responses includes all of the examples that can form hydrogen bonds with water molecules?

D

- I.  $Na^+$
  - II.  $CH_3COOH$
  - III.  $C_2H_6$
  - IV.  $CH_3NH_2$
- A. I and II
  - B. I and III
  - C. II and III
  - D. II and IV
  - E. III and IV



20. Which one of these involves ion-dipole interactions?

E

- A.  $Na^+$  and  $Cl^-$
- B.  $H^+$  and  $F^-$
- C.  $Na^+$  and  $Mg^{2+}$
- D. two water molecules
- E.  $Na^+$  and  $H_2O$

- Are between ions (cation or anion) &  $H_2O$  molecules

- ion-dipole forces are intermolecular forces

- A) Ionic bonding - Intra molecular forces
- B) same as A
- C) same as A & B
- D) Hydrogen bonding
- E) ion-dipole forces

21. Gold crystallizes in an face-centered cell arrangement. What is the density of gold in g/cm<sup>3</sup> if the edge length of a gold unit cell is 409 pm? (1 cm = 10<sup>10</sup> pm).

19.1 g/cm<sup>3</sup>     Density =  $\frac{\text{mass}}{\text{volume}}$

1) To calculate volume:

$$409 \text{ pm} \times \frac{1 \text{ cm}}{10^{10} \text{ pm}} = 4.09 \times 10^{-8} \text{ cm}$$

$$\therefore \text{Volume} = l^3 = (4.09 \times 10^{-8} \text{ cm})^3 = 6.8417929 \times 10^{-25} \text{ cm}^3$$

2) Mass of one atom:

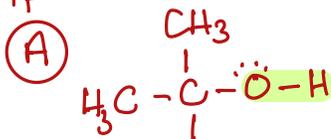
$$4 \text{ Au atoms} \times \frac{1 \text{ mol Au}}{6.022 \times 10^{23} \text{ Au atoms}} \times \frac{196.97 \text{ g Au}}{1 \text{ mol Au}} = 1.3083361 \times 10^{-21} \text{ g Au}$$

$$3) \text{ Density} = \frac{1.3083361 \times 10^{-21} \text{ g}}{6.8417929 \times 10^{-25} \text{ cm}^3} = 19.12270832 \text{ g/cm}^3 \approx 19.1 \text{ g/cm}^3$$

22. Which of the compounds below is expected to have the

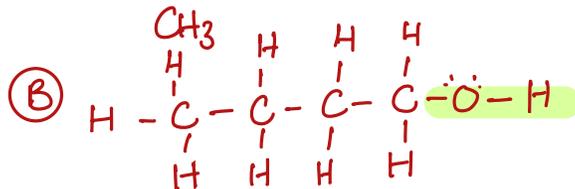
1. **highest** vapor pressure?     *weakest IMF*

A



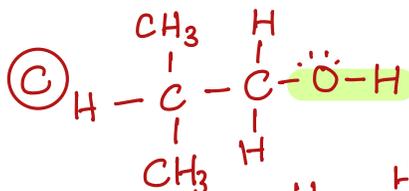
2. **lowest** melting point?

A

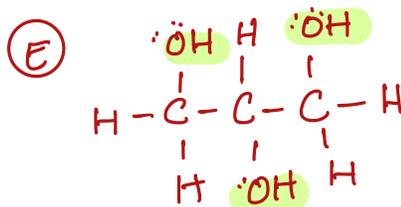
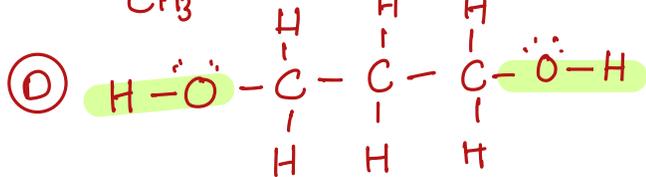


3. **highest** viscosity?

E



- A. (CH<sub>3</sub>)<sub>3</sub>COH
- B. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH
- C. (CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>OH
- D. OHCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH
- E. OHCH<sub>2</sub>CHOHCH<sub>2</sub>OH



\* Note that molecules have the ability to form hydrogen bond

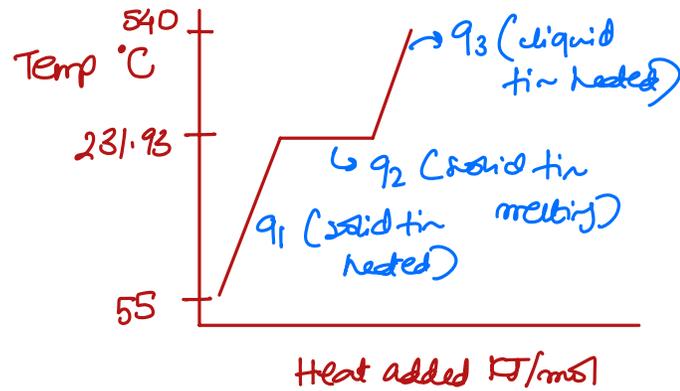
\* You can base your comparison on branching vs. linear molecules (linear has stronger dispersion forces) & number

of hydrogen bonds a molecule can form

23. What is the amount of energy in kJ required to convert 17.0 g of solid tin metal (118.71 g/mol) at 55 °C to the liquid phase at 540 °C.

Melting point of tin = 231.93 °C  
 Boiling point of tin = 2602 °C  
 Specific heat of tin (solid) = 0.2177 J/g.°C  
 Specific heat of tin (liquid) = 0.2093 J/g.°C  
 $\Delta H_{\text{vap}} = 296.1 \text{ kJ/mol}$   
 $\Delta H_{\text{fus}} = 7.03 \text{ kJ/mol}$

2.8 kJ



$$\textcircled{1} q_1 = m \times C \times \Delta T = 17.0 \text{ g} \times 0.2177 \text{ J/g}\cdot\text{°C} \times (231.93 - 55) \text{ °C}$$

$$= 6.54800257 \times 10^2 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 0.654800257 \text{ kJ}$$

$$\textcircled{2} q_2 = n \times \Delta H_{\text{fus}} = 17.0 \text{ g} \times \frac{1 \text{ mol}}{118.71 \text{ g}} \times 7.03 \frac{\text{kJ}}{\text{mol}} = 1.006739112 \text{ kJ}$$

$$\textcircled{3} q_3 = m \times C \times \Delta T = 17.0 \text{ g} \times 0.2093 \text{ J/g}\cdot\text{°C} \times (540 - 231.93) \text{ °C}$$

$$= 1.096143867 \times 10^3 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 1.096143867 \text{ kJ}$$

$$\therefore q_{\text{total}} = q_1 + q_2 + q_3 = 2.757683216 \text{ kJ} \approx 2.8 \text{ kJ}$$

24. Nickel (58.693 g/mol) crystallizes in a face-centered cubic lattice. The density of it is 8.91 g/cm<sup>3</sup>. What is the volume of a single unit cell in nm<sup>3</sup>? (1 nm = 1 × 10<sup>-9</sup> m)

0.0438 nm<sup>3</sup>

$$\textcircled{1} \text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\textcircled{2} \text{Mass of one Ni atom} = 4 \text{ Ni atoms} \times \frac{1 \text{ mol Ni}}{6.02 \times 10^{23} \text{ Ni}} \times \frac{58.69 \text{ g Ni}}{1 \text{ mol Ni}} = 3.89837263 \times 10^{-22} \text{ g}$$

$$\textcircled{3} 8.91 \text{ g/cm}^3 = \frac{3.89837263 \times 10^{-22} \text{ g}}{\text{Volume}}$$

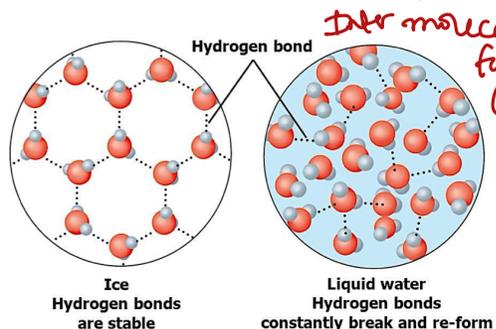
$$\text{Volume} = 4.37527793 \times 10^{-23} \text{ cm}^3 \times \left( \frac{10^{-2} \text{ m}}{1 \text{ cm}} \right)^3 \times \left( \frac{1 \text{ nm}}{10^{-9} \text{ m}} \right)^3$$

$$= 0.0437527793 \text{ nm}^3 \approx 0.0438 \text{ nm}^3$$

25. Both ice and silicon dioxide can form tetrahedral bonding arrangements in the solid phase. Ice is \_\_\_\_\_, while silicon dioxide is \_\_\_\_\_.

**D**

- A. a molecular solid; a metallic solid
- B. a molecular solid; an ionic solid
- C. a network covalent solid; a molecular solid
- D. a molecular solid; a network covalent solid
- E. an ionic solid; a network covalent solid



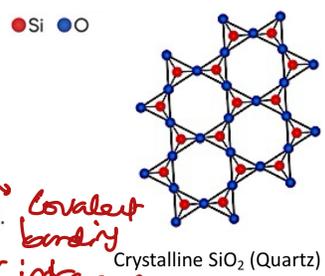
*Inter molecular forces (molecular compound)*



Silicon occupies the center of the tetrahedron, and one oxygen atom occupies each corner.



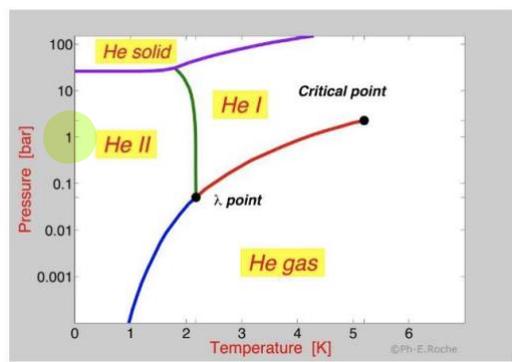
*Covalent bonding (intra molecular forces) - Network covalent*



26. Helium exhibits two liquid phases, He I, and He II, a superfluid. When does helium become a solid, at atmospheric pressure?

**E**

- A. 6 K
- B. 4 K
- C. 2 K
- D. <1 K
- E. Helium cannot become a solid at atmospheric pressure



*From the phase diagram below there is no possible temperature at which He (l) can become a solid*

27. For a particular liquid, raising its temperature from 339 K to 365 K causes its vapor pressure to double. What is the enthalpy of vaporization of this liquid? (R = 8.3145 J/(K·mol))

**A**

- A. 27 kJ/mol
- B. 221 kJ/mol
- C. 3 kJ/mol
- D. 307 kJ/mol
- E. 149 kJ/mol

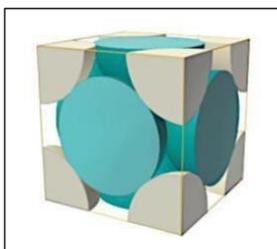
$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

*P<sub>1</sub>  
T<sub>1</sub> = 339 K  
P<sub>2</sub> = 2P<sub>1</sub>  
T<sub>2</sub> = 365 K*

$$\ln\left(\frac{2P_1}{P_1}\right) = \frac{\Delta H_{vap}}{8.314 \times 10^{-3} \frac{kJ}{mol \cdot K}} \left(\frac{1}{339} - \frac{1}{365}\right) \quad R = 8.3145 \times 10^{-3} \frac{kJ}{mol \cdot K}$$

$$\Delta H_{vap} = 27.42550896 \text{ kJ/mol} \approx 27 \text{ kJ/mol}$$

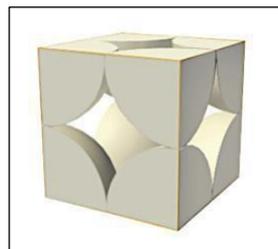
28. Label each of the unit cells below (Insert FCC for face-center cubic; BCC for body-center cubic; or simple cubic)



FCC



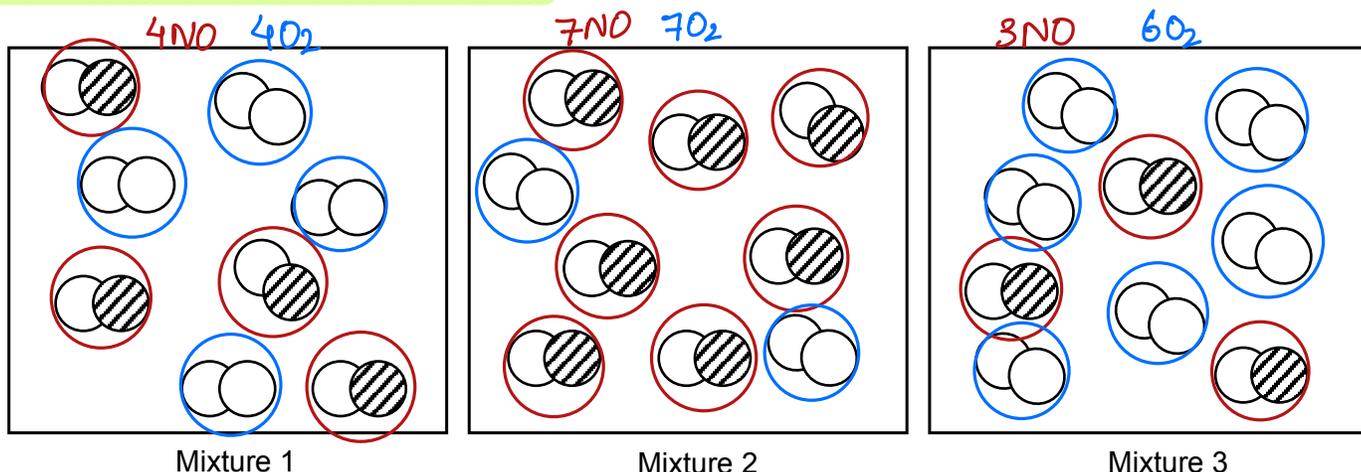
BCC



simple cubic

29. The diagrams represent mixtures of NO(g) and O<sub>2</sub>(g). These two substances react as follows:  
 $2 \text{NO}(g) + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g)$

It has been determined experimentally that the rate is second order in NO and first order in O<sub>2</sub>. Which of the mixtures will have the fastest initial rate?



B

- A. Mixture 1
- B. Mixture 2
- C. Mixture 3
- D. All the reaction mixtures have the same initial rate.

\* From the question, rate =  $k[\text{NO}]^2[\text{O}_2]$

\* strategy: determine the rate of each mixture by plugging in the number of molecules of NO<sub>2</sub> & O<sub>2</sub> in the rate law

Mixture 1: rate =  $k[4]^2[4] = 64$

Mixture 2: rate =  $k[7]^2[2] = 98$

Mixture 3: rate =  $k[3]^2[6] = 54$

30. The reaction  $2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{NO}_2(\text{g})$  has the rate law:  $\text{Rate} = k[\text{NO}]^2[\text{O}_2]$ . If the concentration of NO is reduced by a factor of two and concentration of  $\text{O}_2$  stays the same, the rate will

C

- A. double
- B. quadruple
- C. Reduce by a factor of four
- D. Reduce by a factor of two
- E. Remain the same

Say you hypothetically have two experiments:

$$\text{Exp 1: Rate} = k[\text{NO}]^2[\text{O}_2]$$

$$\text{Exp 2: Rate} = k\left[\frac{1}{2}\text{NO}\right]^2[\text{O}_2]$$

$$\therefore \frac{\text{Exp 2}}{\text{Exp 1}} = \frac{k\left[\frac{1}{2}\text{NO}\right]^2[\text{O}_2]}{k[\text{NO}]^2[\text{O}_2]} = \frac{\frac{1}{4}[\text{NO}]^2}{[\text{NO}]^2} = \frac{1}{4} \rightarrow \text{the rate will be reduced by a factor of four}$$

31. For the reaction  $8 \text{H}_2\text{S}(\text{g}) + 4 \text{O}_2(\text{g}) \rightarrow 8 \text{H}_2\text{O}(\text{g}) + \text{S}_8(\text{g})$  how does the rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  compare to the rate of consumption of  $\text{O}_2(\text{g})$ ?

E

- A. The rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  is  $\frac{1}{2}$  the rate of consumption of  $\text{O}_2(\text{g})$ .
- B. The rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  is the same rate consumption of  $\text{O}_2(\text{g})$ .
- C. The rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  is 8 times the rate consumption of  $\text{O}_2(\text{g})$ .
- D. The rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  is 4 times the rate of consumption of  $\text{O}_2(\text{g})$ .
- E. The rate of disappearance of  $\text{H}_2\text{S}(\text{g})$  is twice the rate of consumption of  $\text{O}_2(\text{g})$ .

$$\text{Rate} = -\frac{1}{8} \frac{\Delta[\text{H}_2\text{S}]}{\Delta t} = -\frac{1}{4} \frac{\Delta[\text{O}_2]}{\Delta t} = +\frac{1}{8} \frac{\Delta[\text{H}_2\text{O}]}{\Delta t} = -\frac{\Delta[\text{S}_8]}{\Delta t}$$

$$8 \times -\frac{1}{8} \frac{\Delta[\text{H}_2\text{S}]}{\Delta t} = -\frac{1}{4} \frac{\Delta[\text{O}_2]}{\Delta t} \times 8$$

$$\therefore \frac{\Delta[\text{H}_2\text{S}]}{\Delta t} = 2 \frac{\Delta[\text{O}_2]}{\Delta t}$$

32. Consider the reaction:  $2\text{NH}_3(\text{g}) \rightarrow \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$ . If the rate of  $\Delta[\text{H}_2]/\Delta t$  is  $0.030 \text{ mol L}^{-1}\text{s}^{-1}$ , then  $\Delta[\text{NH}_3]/\Delta t$  is

C

- A.  $-0.045 \text{ mol L}^{-1} \text{ s}^{-1}$
- B.  $-0.030 \text{ mol L}^{-1} \text{ s}^{-1}$
- C.  $-0.020 \text{ mol L}^{-1} \text{ s}^{-1}$
- D.  $-0.010 \text{ mol L}^{-1} \text{ s}^{-1}$
- E. None of these choices are correct.

$$\text{Rate} = -\frac{1}{2} \frac{\Delta[\text{NH}_3]}{\Delta t} = +\frac{\Delta[\text{N}_2]}{\Delta t} = +\frac{1}{3} \frac{\Delta[\text{H}_2]}{\Delta t}$$

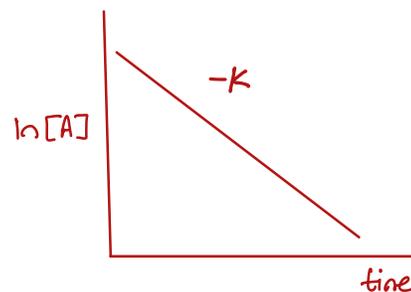
$$-\frac{1}{2} \frac{\Delta[\text{NH}_3]}{\Delta t} = +\frac{1}{3} (0.030)$$

$$\therefore \frac{\Delta[\text{NH}_3]}{\Delta t} = -0.020 \text{ mol/L}\cdot\text{s}$$

33. When the reaction  $A \rightarrow B + C$  is studied, a plot of  $\ln[A]t$  vs. time gives a straight line with a negative slope. What is the order of the reaction?

**B**

- A. Zero
- B. First
- C. Second
- D. Third
- E. More information is needed to determine the order.



| Order | Rate Law        | Units of k            | Integrated Rate Law  | Straight-Line Plot | Half-Life Expression   |
|-------|-----------------|-----------------------|--|--------------------|--|
| 0     | Rate = $k[A]^0$ | $M \cdot s^{-1}$      | $[A]_t = -kt + [A]_0$  |                    | $t_{1/2} = \frac{[A]_0}{2k} = \frac{1}{k} \cdot \frac{[A]_0}{2}$ |
| 1     | Rate = $k[A]^1$ | $s^{-1}$              | $\ln[A]_t = -kt + \ln[A]_0$<br>$\ln \frac{[A]_t}{[A]_0} = -kt$ |                    | $t_{1/2} = \frac{0.693}{k} = \frac{1}{k} (0.693)$                |
| 2     | Rate = $k[A]^2$ | $M^{-1} \cdot s^{-1}$ | $\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$                       |                    | $t_{1/2} = \frac{1}{k[A]_0} = \frac{1}{k} \cdot \frac{1}{[A]_0}$ |

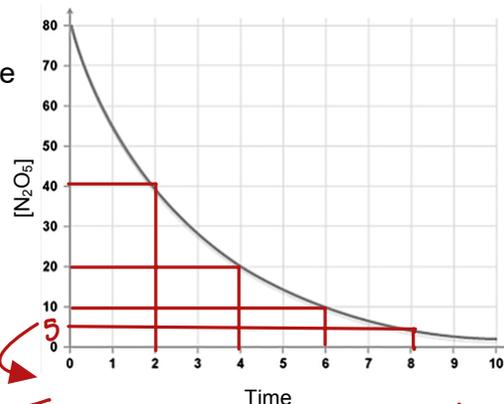
→ You need to know the plot for each of the reaction orders

34. Using the graphical representation below of the concentration of  $N_2O_5$  versus time for the reaction  $N_2O_5(g) \rightarrow NO_3(g) + NO_2(g)$ , which of the statements is false?

**A**

- A. The decomposition of  $N_2O_5$  follows zero order kinetics.
- B. It takes about 2 minutes for  $N_2O_5$  to decrease to half of its original concentration.
- C. The half-life of this reaction is independent of the original concentration of  $N_2O_5$ .
- D. The rate for this reaction can be expressed as rate =  $k [N_2O_5]$

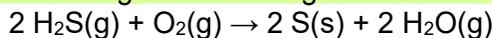
choices B, C, D are correct & consistent with first-order kinetics



From this plot of  $[N_2O_5]$  vs. time it takes 2 minutes for the conc of  $N_2O_5$  to drop to half of its original concentration characteristic of first-order half-life

35. Which of the statements is true concerning the reaction given below?

**E**



- ~~A.~~ The rate law is Rate =  $k[H_2S]^2[O_2]$ .
- ~~B.~~ The reaction is second-order in  $H_2S(g)$  and first-order in  $O_2(g)$ .
- ~~C.~~ The reaction is first-order in  $H_2S(g)$  and second-order in  $O_2(g)$ .
- ~~D.~~ The rate law is Rate =  $k[H_2S][O_2]$ .
- E. The rate law must be determined by experiments.

the rate law must be determined by experiments & not from the equation.

36. For the reaction  $A + B + C \rightarrow \text{products}$ , this initial-rate data were obtained for five experiments.

| Experiment No. | [A] <sub>0</sub> (mol/L) | [B] <sub>0</sub> (mol/L) | [C] <sub>0</sub> (mol/L) | Initial Rate (mol/(L·s)) |
|----------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1)             | 0.40                     | 0.40                     | 0.20                     | 0.0160                   |
| 2)             | 0.20                     | 0.40                     | 0.40                     | 0.0080                   |
| 3)             | 0.60                     | 0.10                     | 0.20                     | 0.0015                   |
| 4)             | 0.20                     | 0.10                     | 0.20                     | 0.0005                   |
| 5)             | 0.20                     | 0.20                     | 0.40                     | 0.0020                   |

$$\text{Rate} = k [A]^x [B]^y [C]^z$$

What are the reaction orders with respect to A, B, and C, respectively?

**D**

- A. 0, 1, 1
- B. 1, 2, 1
- C. 1, 1, 1
- D. 1, 2, 0
- E. 0, 2, 1

1) To determine the order with respect to A (Exp. 3 & 4)

$$\frac{\text{Exp 4}}{\text{Exp 3}} = \frac{k [A]_4^x [B]_4^y [C]_4^z}{k [A]_3^x [B]_3^y [C]_3^z}$$

$$\frac{0.0005}{0.0015} = \frac{[0.20]^x [0.10]^y [0.20]^z}{[0.60]^x [0.10]^y [0.20]^z}$$

$$\frac{1}{3} = \left(\frac{1}{3}\right)^x$$

$\therefore x = 1$

3) To determine the order with respect to C (Exp 1 & 4)

$$\frac{\text{Exp 4}}{\text{Exp 1}} = \frac{k [A]_4^x [B]_4^y [C]_4^z}{k [A]_1^x [B]_1^y [C]_1^z}$$

$$\frac{0.0005}{0.0160} = \frac{[0.20] [0.10] [0.20]^z}{[0.40] [0.40]^2 [0.20]^z}$$

$$0.03125 = 0.03125 [ ]^z$$

$$1 = [ ]^z$$

$$\therefore z = 0$$

2) To determine the order with respect to B (Exp. 2 & 5)

$$\frac{\text{Exp 5}}{\text{Exp 2}} = \frac{k [A]_5^x [B]_5^y [C]_5^z}{k [A]_2^x [B]_2^y [C]_2^z}$$

$$\frac{0.0020}{0.0080} = \frac{[0.20] [0.20]^y [0.40]^z}{[0.20] [0.40]^y [0.40]^z}$$

$$\therefore \frac{1}{4} = \left(\frac{1}{2}\right)^y$$

$\therefore y = 2$

37. Carbon-14, which is present in all living tissue, radioactively decays via a first-order process. A one-gram sample of wood taken from a living tree gives a rate for carbon-14 decay of 13.6 counts per minute. If the half-life for carbon-14 is 5720 years, how old (in years) is a wood sample that gives a rate for carbon-14 decay of 11.9 counts per minute?

**1.10 × 10<sup>3</sup>**

Years

$$\ln [A]_t = -kt + \ln [A]_0$$

$$\ln [11.9] = -1.21179577 \times 10^{-4} \times t + \ln [13.6]$$

$$\therefore t = 1.101929846 \times 10^3 \text{ yr}$$

$$\approx 1.10 \times 10^3 \text{ years}$$

$$[A]_0 = 13.6 \text{ counts/minute}$$

$$[A]_t = 11.9 \text{ counts/minute}$$

$$t = ?$$

K = determine from first order half-life

$$\therefore t_{1/2} = \frac{\ln 2}{k}$$

$$5720 = \frac{\ln 2}{k}$$

$$\therefore k =$$

$$1.21179577 \times 10^{-4} \text{ yr}^{-1}$$

38. The bromination of acetone occurs according to:  $\text{CH}_3\text{COCH}_3 + \text{Br}_2 \rightarrow \text{CH}_3\text{COCH}_2\text{Br} + \text{Br}^-$  and is catalyzed by  $\text{H}_3\text{O}^+$ . The rate of disappearance of bromine was measured for several different concentrations of acetone, bromine, and  $\text{H}_3\text{O}^+$  at a certain temperature:

|    | $[\text{CH}_3\text{COCH}_3]$ | $[\text{Br}_2]$ | $[\text{H}_3\text{O}^+]$ | Rate of disappearance of $[\text{Br}_2]$ |
|----|------------------------------|-----------------|--------------------------|--|
| 1. | 0.3                          | 0.05            | 0.05                     | $5.7 \times 10^{-5}$                     |
| 2. | 0.3                          | 0.1             | 0.05                     | $5.7 \times 10^{-5}$                     |
| 3. | 0.3                          | 0.06            | 0.10                     | $1.2 \times 10^{-4}$                     |
| 4. | 0.4                          | 0.05            | 0.2                      | $3.1 \times 10^{-4}$                     |
| 5. | 0.4                          | 0.05            | 0.3                      | $4.6 \times 10^{-4}$                     |

What is the rate law for the reaction? (Note: make sure to consider  $\text{H}_3\text{O}^+$  as part of the reaction)

B

- A. Rate =  $k[\text{CH}_3\text{COCH}_3][\text{Br}_2]$   
 B. Rate =  $k[\text{CH}_3\text{COCH}_3][\text{H}_3\text{O}^+]$   
 C. Rate =  $k[\text{CH}_3\text{COCH}_3][\text{Br}_2][\text{H}_3\text{O}^+]$   
 D. Rate =  $k[\text{CH}_3\text{COCH}_3]^2$   
 E. Rate =  $k[\text{CH}_3\text{COCH}_3]^2[\text{H}_3\text{O}^+]$

we can write the rate as  
 Rate =  $k[\text{CH}_3\text{COCH}_3]^x[\text{Br}_2]^y[\text{H}_3\text{O}^+]^z$

① to determine the order with respect to  $[\text{Br}_2]$  (Experiments 1 & 2)

$$\frac{\text{Rate Exp 2}}{\text{Rate Exp 1}} = \frac{k[\text{CH}_3\text{COCH}_3]_2^x [\text{Br}_2]_2^y [\text{H}_3\text{O}^+]_2^z}{k[\text{CH}_3\text{COCH}_3]_1^x [\text{Br}_2]_1^y [\text{H}_3\text{O}^+]_1^z}$$

$$\frac{5.7 \times 10^{-5}}{5.7 \times 10^{-5}} = \frac{[0.3]^x [0.1]^y [0.05]^z}{[0.3]^x [0.05]^y [0.05]^z}$$

$$\therefore 1 = \frac{[0.1]^y}{[0.05]^y} \quad \therefore 1 = \left(\frac{0.1}{0.05}\right)^y \quad \therefore 1 = 2^y$$

$$\therefore y = 0$$

② to determine the order with respect to  $[\text{H}_3\text{O}^+]$  (Experiments 4 & 5)

$$\frac{4.6 \times 10^{-4}}{3.1 \times 10^{-4}} = \frac{k[0.4]^x [0.05]^y [0.3]^z}{k[0.4]^x [0.05]^y [0.2]^z}$$

$$1.483870968 \approx 1.5 = (1.5)^z$$

$$\therefore z = 1$$

③ to determine the order with respect to  $[\text{CH}_3\text{COCH}_3]$  (Exp. 3 & 4)

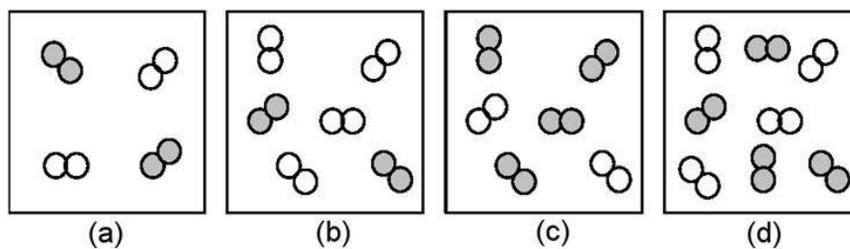
$$\frac{3.1 \times 10^{-4}}{1.2 \times 10^{-4}} = \frac{k[0.4]^x [0.05]^y [0.20]^z}{k[0.3]^x [0.06]^y [0.10]^z}$$

$$1.291666667 = (1.333333333)^x$$

$$\therefore x = 1$$

Rate law =  
 $k[\text{CH}_3\text{COCH}_3][\text{H}_3\text{O}^+]$

39. The relative initial rates of the reaction  $A_2 + B_2 \rightarrow$  products in vessels (a)-(d) are 1:1:4:4. Unshaded spheres represent  $A_2$  molecules, and shaded spheres represent  $B_2$  molecules present at the beginning of the reaction. What is the overall order of the reaction?



C

- A. 0  
B. 1  
C. 2  
D. 3

| Experiment | $[A_2]$ | $[B_2]$ | Initial rate |
|------------|---------|---------|--------------|
| (a)        | 2       | 2       | 1            |
| (b)        | 4       | 2       | 1            |
| (c)        | 2       | 4       | 4            |
| (d)        | 4       | 4       | 4            |

$$\text{Rate} = k[A_2]^x[B_2]^y$$

① to determine the order with respect to  $A_2$  (Exp a & b)

$$\frac{\text{Exp(b)}}{\text{Exp(a)}} = \frac{k[A_2]_b^x[B_2]_b^y}{k[A_2]_a^x[B_2]_a^y}$$

$$\frac{1}{1} = \frac{[2]^x [2]^y}{[4]^x [2]^y}$$

$$1 = \left(\frac{1}{2}\right)^x \therefore x = 0$$

② to determine the order with respect to  $B_2$  (Exp (b) & (d))

$$\frac{\text{Exp(d)}}{\text{Exp(b)}} = \frac{k[A_2]_d^x[B_2]_d^y}{k[A_2]_b^x[B_2]_b^y}$$

$$\frac{4}{1} = \frac{[4]^0 [4]^y}{[4]^0 [2]^y}$$

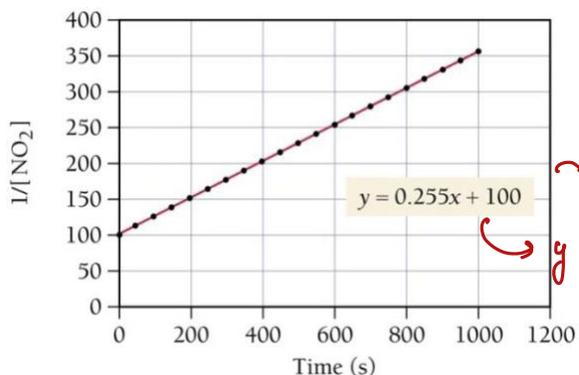
$$4 = 2^y \therefore y = 2$$

$$\text{③ Rate} = [A_2]^0 [B_2]^2$$

$$\therefore \text{Rate} = [B_2]^2$$

$$\therefore \text{overall order} = 2$$

40. Consider the following graph, which depicts the change in the concentration of NO over time.



→ this graph represents second-order kinetics

$$y = mx + b$$

$$m = \text{slope} = k = 0.255$$

If the initial concentration of NO<sub>2</sub> is 0.01 M, how long will it take for the NO<sub>2</sub> concentration to decrease to 10% of its initial concentration?

$$3.5 \times 10^2 \text{ s}$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A]_0 = 0.01 \text{ M}$$

Remaining  $\leftarrow [A]_t = 10\% \times 0.01 = 0.0010$   
is 90%  $t = ?$

$$k = 0.255 \text{ M}^{-1} \cdot \text{s}^{-1}$$

$$\frac{1}{0.0010} = 0.255t + \frac{1}{0.01 \text{ M}}$$

$$\therefore 900 = 0.255t$$

$$t = 3529.411765 \text{ sec}$$

$$\sim 3500 \text{ s} = 3.5 \times 10^2 \text{ s}$$

41. In a second order reaction:

- I) the sum of the exponents in the rate law is equal to two.
- II) at least one of the exponents in the rate law is a two.
- III) the half-life is dependent on the initial concentration of the reactant species.
- IV) the half-life is independent of the initial concentration of the reactant species.
- V)  $k$  can be expressed as  $\text{M}^{-2} \text{s}^{-1}$  or  $\text{M}^{-2} \text{min}^{-1}$ .

→ this is third order

i) Rate =  $[A][B]$  overall order = 2  
 $\rightarrow$  Rate =  $[A]^2$  overall order = 2

ii) Rate not necessarily 2

iii)  $t_{1/2} = \frac{1}{k[A]_0}$  → dependant on initial conc

iv) this applies only for first-order half-life

v) Rate =  $k[A]^2$   
 $\text{M/s} = k[\text{M}]^2$   
 $k = \text{M}^{-1} \text{s}^{-1}$

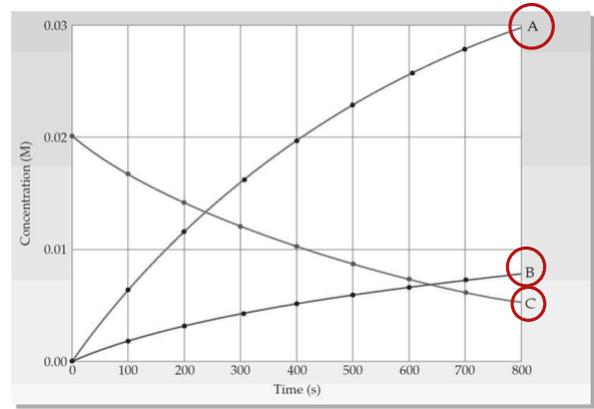
D

- A. I and IV
- B. II and IV
- C. I, III, and V
- D. I and III
- E. II and III

42. Shown is a concentration versus time plot for a reaction involving gases A, B, and C. Which equation best represents the reaction?

C

- A.  $4 A(g) \rightarrow B(g) + 2 C(g)$
- B.  $4 A(g) + B(g) \rightarrow 2 C(g)$
- C.  $2 C(g) \rightarrow 4 A(g) + B(g)$
- D.  $2 C(g) + B(g) \rightarrow 4 A(g)$



\* In a chemical reaction, the conc of reactants decrease over time & that of products increases

∴ C is the reactant as its conc decreases over time & A & B are products since their conc increases

43. The second-order reaction  $2 Mn(CO)_5 \rightarrow Mn_2(CO)_{10}$  has a rate constant equal to  $3.0 \times 10^9 L/mol \cdot s$  at  $25^\circ C$ . If the initial concentration of  $Mn(CO)_5$  is  $2.0 \times 10^{-5} mol/L$ , how long will it take (in seconds) for 90% of the reactant to disappear?

$1.5 \times 10^{-4}$

$$s \quad \frac{1}{[A]} = kt + \frac{1}{[A]_0} \text{ remaining}$$

$$\frac{1}{[2.0 \times 10^{-6}]} = 3.0 \times 10^9 t + \frac{1}{[2.0 \times 10^{-5}]}$$

$$4.5 \times 10^5 = 3.0 \times 10^9 t$$

$$\therefore t = 1.5 \times 10^{-4} s$$

$$k = 3.0 \times 10^9 L/mol \cdot s$$

$$[A]_0 = 2.0 \times 10^{-5} mol/L$$

$$t = ?$$

$$[A]_t = 10\% \times 2.0 \times 10^{-5}$$

$$= 2.0 \times 10^{-6} mol/L$$

↪ means that  $100 - 87.5 = 12.5\%$

44. A first order reaction is observed to be 87.5% complete in 1200 s. What is the half-life in seconds for this reaction?

$4.0 \times 10^2$  s

$$\ln \frac{[A]}{[A]_0} = -kt$$

$[A]_t = 12.5\%$   
 $[A]_0 = 100\%$   
 $t = 1200$   
 $k = ?$

①  $\ln \left( \frac{12.5}{100} \right) = -k(1200)$   
 $\therefore k = 1.732867951 \times 10^{-3} \text{ s}^{-1}$  (2 sig figs)

②  $t_{1/2} = \frac{\ln 2}{k}$   
 $\therefore t_{1/2} = \frac{\ln 2}{1.732867951 \times 10^{-3}} = 4.0 \times 10^2 \text{ sec}$

45. For question 45, a first-order reaction, how long does it take in seconds to reach 95% completion?

$1.7 \times 10^2$  s

$$\ln \left( \frac{100 - 95}{100} \right) = -1.732867951 \times 10^{-3} t$$

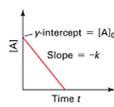
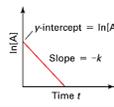
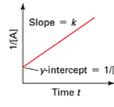
$\therefore t = 1728.771238 \text{ s}$   
 $\sim 1700 = 1.7 \times 10^2 \text{ s}$

second order

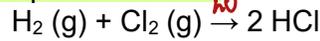
46. Data is collected for the reaction  $A \rightarrow B + C$ , demonstrating a straight line with a positive slope when plotted as  $1/[A]$  vs time. The reaction exhibits (select all the apply, use the letters with no commas):

BEH

- A. a half-life independent of concentration
- B. a half-life inversely proportional to concentration
- C. a half-life directly proportional to concentration
- D. a half-life proportional to k
- E. a half-life inversely proportional to k
- F. 0th order kinetics
- G. 1st order kinetics
- H. 2nd order kinetics

| Order | Rate Law        | Units of k            | Integrated Rate Law  | Straight-Line Plot  | Half-Life Expression                                       |
|-------|-----------------|-----------------------|--|---|--|
| 0     | Rate = $k[A]^0$ | $M \cdot s^{-1}$      | $[A]_t = -kt + [A]_0$  |  | $t_{1/2} = \frac{[A]_0}{2k} = \frac{1}{k} \frac{[A]_0}{2}$ |
| 1     | Rate = $k[A]^1$ | $s^{-1}$              | $\ln[A]_t = -kt + \ln[A]_0$<br>$\ln \frac{[A]_t}{[A]_0} = -kt$ |  | $t_{1/2} = \frac{0.693}{k} = \frac{1}{k} (0.693)$          |
| 2     | Rate = $k[A]^2$ | $M^{-1} \cdot s^{-1}$ | $\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$                       |  | $t_{1/2} = \frac{1}{k[A]_0} = \frac{1}{k} \frac{1}{[A]_0}$ |

47. Photochemical reactions depend upon the reactants absorbing radiation. Hydrogen and chlorine will react to produce hydrochloric acid if sunlight is present. What is the order of this reaction?



A

- A. 0th order  
B. 1st order  
C. 2nd order  
D. There is not enough information to determine the reaction order

photochemical reactions like the one mentioned in the question depends on the number of photons introduced to the reaction  
∴ if you increase the conc of H<sub>2</sub> or Cl<sub>2</sub> the rate of the reaction stays the same ∴ zero-order

48. The decomposition of ammonia to nitrogen gas and hydrogen gas on a platinum wire follows zero order reaction kinetics. If the concentration of ammonia is doubled, then the rate of the reaction

A

- A. Stays the same  
B. Doubles  
C. Quadruples  
D. Becomes zero

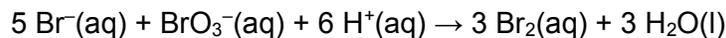


$$\text{Rate} = k[\text{NH}_3]^0$$

$$\therefore \text{Rate} = k$$

∴ rate is independent on the conc of NH<sub>3</sub>

49. The rate law for the chemical reaction



- has been determined experimentally to be  $\text{Rate} = k[\text{Br}^-][\text{BrO}_3^-][\text{H}^+]^2$ . What is the overall order of the reaction?

D

- A. 1  
B. 2  
C. 3  
D. 4  
E. 5

$$\text{overall order} = 1 + 1 + 2 = 4$$

50. At a given temperature, a first-order reaction has a rate constant of  $2.5 \times 10^{-3} \text{ s}^{-1}$ . How long will it take for the reaction to be 35% complete?

E

- A. 420 s  
B. 1600 s  
C. 1400 s  
D. 74 s  
E. 170 s

$$\ln \frac{[A]}{[A]_0} = -kt$$

$$\ln \left( \frac{65}{100} \right) = -2.5 \times 10^{-3} t$$

$$\therefore t = 172.3131664 \text{ s} \approx 170 \text{ s}$$

$$\begin{aligned} [A]_0 &= 100\% \\ [A]_t(\text{remaining}) &= 100 - 35 = 65\% \\ k &= 2.5 \times 10^{-3} \text{ s}^{-1} \\ t &=? \end{aligned}$$

51. Experiment shows that the reaction below is first order:  $A \rightarrow P$  Answer the questions based on the kinetic information in the table.

| Time (s) | $\ln[A]$ |
|----------|----------|
| 1.0      | -1.659   |
| 2.0      | -2.209   |

*Handwritten notes:*  
 - this conc. at  $t = 1.0$  sec can be considered as initial conditions  
 - Note that this is the natural log of  $[A]$   $\therefore$  can be plugged directly into the equation  
 - this can be considered the conditions after 2.0 seconds

A. What is the numerical value of the rate constant for this reaction?

0.55

$s^{-1}$

$$\ln [A]_{2.0} = -kt + \ln [A]_{1.0}$$

$$-2.209 = -k(2.0 - 1.0)s + (-1.659)$$

$$\therefore k = 0.55 s^{-1}$$

B. What was the initial concentration of A?

0.33

M

$$\ln [A]_t = -kt + \ln [A]_0$$

$$-2.209 = -0.55s^{-1}(2.0s) + \ln [A]_0$$

$$\therefore \ln [A]_0 = -1.109 \rightarrow \text{take 'e' of both sides}$$

$$\therefore [A]_0 = 0.32988868 \sim 0.330M$$

C. What would the concentration of A be after 4.0 seconds?

0.037

M

$$\ln [A]_t = -kt + \ln [A]_0$$

$$\ln [A]_t = -0.55(4) + \ln [0.330]$$

$$\ln [A]_t = -3.30866 \rightarrow \text{take 'e' of both sides}$$

$$\therefore [A]_{4.0} = 0.036565M \sim 0.037M$$

D. What is the half-life (in seconds) for this reaction?

1.3

s

$$t_{1/2} = \frac{\ln 2}{k} = \frac{\ln 2}{0.55s^{-1}} = 1.260267sec \sim 1.3 sec$$