

States of Matter- Free Response

Short Answer

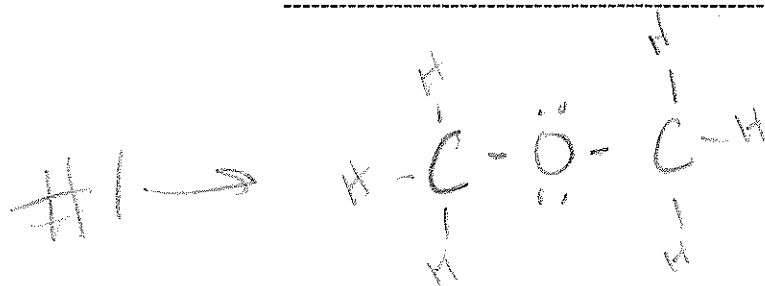
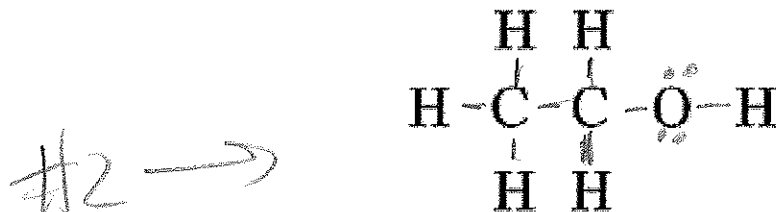
1.

Compound	Empirical formula	Solubility in water	Boiling point (C)
1	C ₂ H ₆ O	Slightly Soluble	-24
2	C ₂ H ₆ O	Soluble	78

Compounds 1 and 2 in the data table above have the same empirical formula, but they have different physical properties.

(a) The skeletal structure for one of the two compounds is shown below in Box X.

(i) Complete the Lewis electron-dot diagram of the molecule below. Include any lone (nonbonding) pairs of electrons.



(ii) Above, draw the complete Lewis electron-dot diagram for the other compound (2), which is a structural isomer of the compound represented in Box X. Include any lone (nonbonding) pairs of electrons.

(b) On the basis of the complete Lewis electron-dot diagrams you drew in part (a) and the information in the data table above, identify which compound, 1 or 2, has the structure represented in Box X. Justify your answer in terms of the intermolecular forces present in each compound.

Name	Lewis Structure	Boiling point (C)	Vapor pressure (mmHg)
DiChloral methane	$ \begin{array}{c} \text{H} \\ \vdots \\ \text{:Cl:}\ddot{\text{C}}\text{:H} \\ \vdots \\ \text{:Cl:} \\ \vdots \end{array} $	39.6	353
Carbon Tetra Chloride	$ \begin{array}{c} \vdots \\ \text{:Cl:} \\ \vdots \\ \text{:Cl:}\ddot{\text{C}}\text{:Cl:} \\ \vdots \\ \text{:Cl:} \\ \vdots \end{array} $	76.7	89

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between each of the solutes and water.

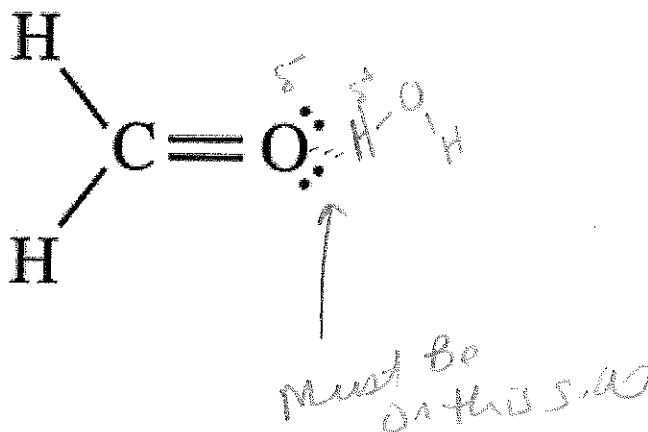
Dichloromethane is not sym - slightly polar - more soluble in H₂O

(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.

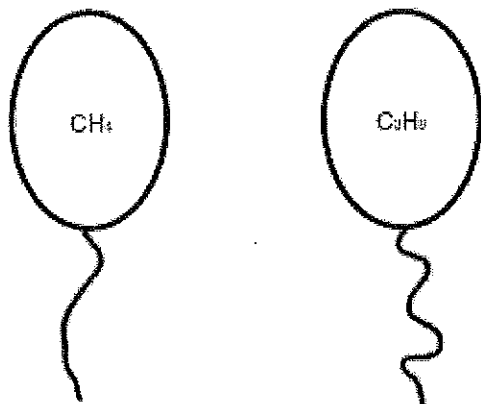
CCl₄ ↑ IMF - more attraction = less VP

(e) The complete Lewis electron-dot diagram of methanal (formaldehyde) is shown in the box below.

Molecules of methanal can form hydrogen bonds with water. In the box below, draw a water molecule in a correct orientation to illustrate a hydrogen bond between a molecule of water and the molecule of methanal. Use a dashed line to represent the hydrogen bond.



Both balloons are subject to a 25°C and 1.25 ATM pressure.

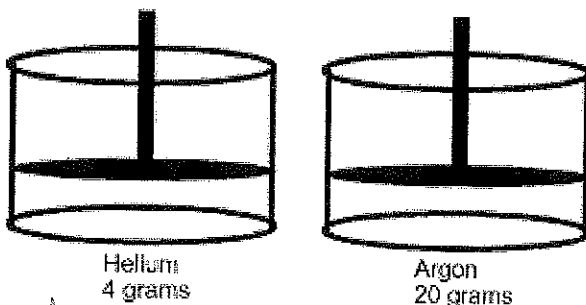


2.

- A. Which balloon has the most particles? *Same*
- B. Which balloon has the greatest molecular velocity? *CH₄*
- C. Which balloon, if compressed would condense to a liquid first? Why? *C₃H₈ ↑LDF*
- D. One of these balloons sinks and one floats in air. Which one floats? *CH₄ lower mass ↓Density*
- E. 24 hours after the contents were added to the balloon, one balloon is significantly smaller, which balloon is this and why? *CH₄ - ↑Molecular Velocity ↑Effusion*
- F. If the contents of the balloons were ignited, which balloon would create the largest production of gaseous products? Why?

C₃H₈ - more atoms to build CO₂ + H₂O

Two pistons, each at the same volume (2.4L) and the same temperature (273K).



$4g \cdot \frac{1 \text{ mol}}{4g} = 1 \text{ mol}$

$20g \cdot \frac{1 \text{ mol}}{40g} = .5 \text{ mol}$

3. A. Which of the two has the highest average kinetic energy? SAME
- B. Which of the two contains the largest number of particles? He \rightarrow See work
- C. Which container has the largest pressure? He - twice "n" $P = \frac{nRT}{V}$
- D. What is the pressure in the Helium piston? $\frac{1 \cdot .0821 \cdot 273}{2.4} = 9.3 \text{ atm}$
- E. If both pistons were compressed equally until 1 substance liquified, which piston would this be? Why
- F. If both of these pistons had the external pressure released therefore allowing the pressure inside of them expand the piston until it reached a pressure equal to that of the atmosphere (1atm) how big would each cylinder expand to?

He = 1 mol = 22.4L Ar = .5 mol = 11.2L

$PV = nRT$

$V = \frac{nRT}{P}$

Solve

or

22.4L = 1 mol

workbook: States of matter (#7-1, #7-2, #7-3, #7-4)

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

1. Which of the following 0.20M water solution has the lowest conductivity?

(Assume ideal behavior)

- a. Urea, $(\text{NH}_2)_2\text{CO}$
- b. Ammonium hydrogen sulfate, NH_4HSO_4
- c. Ammonium chloride, NH_4Cl
- d. Ammonium phosphate, $(\text{NH}_4)_3\text{PO}_4$

Which is NOT ionic

2. Which expression gives the mole fraction of H_2SO_4 in a water solution that contains 3.0 moles of H_2SO_4 in 90 grams of water?

- a. $\frac{3}{5}$
- b. $\frac{3}{8}$
- c. $\frac{3}{90}$
- d. $\frac{(3 \cdot 98)}{(18 \cdot 90)}$
- e. $\frac{(3 \cdot 98)}{(90/18)}$

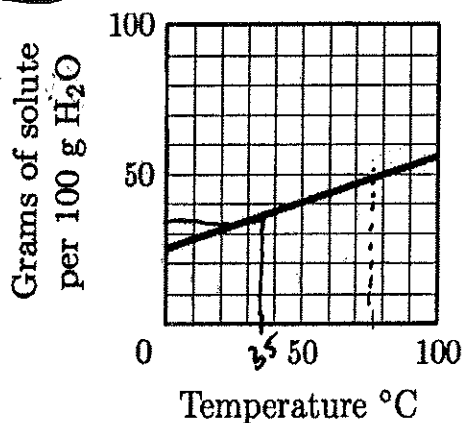
Moles / total moles = X

$\frac{3}{3+5} = \frac{3}{8}$
 $\frac{18}{18} = 1$

3. What is the percent methanol by mass in a solution that contains 20 grams of Methanol, CH_3OH , in 30 grams of water.

- a. 20%
- b. 33%
- c. 40%
- d. 60%
- e. 67%

$\frac{20}{20+30} = \frac{20}{50} = \frac{40}{100} = 40\%$



4. What is the molality of a saturated solution of KCl (molar mass 74.6) at 35°C?

- a. 0.37
- b. 0.50
- c. 2.0
- d. 3.7
- e. 5.0

$\frac{\text{mol}}{\text{L}} = \frac{.5 \text{ mol}}{.1 \text{ L}} = 5$
 $355 - \frac{1 \text{ mol}}{74.6} = .5$
 $100 \text{ g} = 100 \text{ mL} = .1 \text{ L}$

5. A saturated solution of KCl at 75°C contains 100g water. Which value is closest to the percent by mass of KCl in the solution?

- a. 33
- b. 50
- c. 60
- d. 67
- e. 75

50g

$\frac{50}{50+100}$
 $\frac{50}{150} = 33\%$

$\% \text{ Mass} = \frac{\text{Mass}}{\text{total Mass}}$

Name: _____

ID: A

35g dissolves in 100g

6. When the system is cooled from 60 C to 30C, a white crystalline solid forms. Which is the best description of the liquid phase of the system?
- a. 50g solution including 20g solute
 b. 60g solution including 40g solute
 c. 100 g solution including 35g solute
 d. 120 g solution including 20g solute
 e. 135g solution including 35 g solute
7. A mixture containing 100 g of water and 40. g of KCl is warmed to 60C and thoroughly stirred until no further changes occur. The resulting system is best described as
- a. A colloid
 b. a suspension
 c. a saturated solution
 d. an unsaturated solution
 e. an isotonic solution
8. A saturated solution of KNO_3 at equilibrium with excess solute is prepared at 20C. Which of the following describe the solution after the temperature of the system is increases to 40C while still in contact with excess solute?
- I. The molality of the solution increases. ↑
 II. The solution remains saturated. ↑
 III. The density of the solution increases. ↑
- a. II only
 b. III only
 c. I and III only
 d. II and III only
 e. I, II, III
9. Under which of the following conditions of temperature and pressure will H_2 gas be expected to behave most like an ideal gas?
- a. 50 K and 0.10 atm
 b. 50 K and 5.0 atm
 c. 500 K and 0.10 atm
 d. 500 K and 50 atm

↳ 45g

↑T ↓P

The table below contains information about samples of four different gases at 273 K. The samples are in four identical rigid containers numbered 1 through 4.

Container	Gas	Pressure (atm)	Mass of sample (g)
1	He	2.00	?
2	Ne	2.00	?
3	?	2.00	16.0
4	SO_2	1.96	64.1

10. On the basis of the data provided above, the gas in container 3 could be
- a. CH_4
 b. O_2
 c. Ar
 d. CO_2
11. Under the conditions given, consider containers 1, 2, and 4 only. The average speed of the gas particles is
- a. greatest in container 1
 b. greatest in container 2
 c. greatest in container 4
 d. the same in containers 1, 2, and 4

*CH_4
12 + 4 = 16g/mol*

12. The best explanation for the lower pressure in container 4 is that SO₂ molecules *2 vs. 1.96*
- have a larger average speed than the other three gases
 - occupy a larger portion of the container volume than the other three gases
 - Contains a di-pole dipole attraction that causes slight deviation from 2 atm.
 - contain pi bonds, while the other gases contain only sigma bonds
13. What is the mass of the Ne flask?
- 2
 - 4
 - 10
 - 20
14. All of the flasks have the same volume, what is the volume of the flasks? *2 ATM*
- 1L
 - 2.2L
 - 11.2L
 - 33.8L
15. Which of the following could be the identity of a white crystalline solid that exhibits the following properties?
- It melts at 320C.
 - It does not conduct electricity as a solid.
 - It conducts electricity in an aqueous solution.) *ionic*
- C₆H₁₂O₆ solid
 - NaOH solid
 - SiO₂ solid
 - Cu solid
16. The bottler of a carbonated beverage dissolves carbon dioxide in water by placing CO₂ in contact with water at a pressure of 1atm at room temperature. The best way to increase the amount of dissolved CO₂ would be to
- increase the temperature and increase the pressure of CO₂
 - decrease the temperature and decrease the pressure of CO₂
 - decrease the temperature and increase the pressure of CO₂
 - increase the temperature without changing the pressure of CO₂
 - increase the pressure of CO₂ without changing the temperature.
17. (#7-3c) Which of the following expressions represents the density of Helium at STP? *$\frac{1 \text{ mol}}{22.4 \text{ L}} = \frac{4 \text{ g}}{22.4 \text{ L}}$*
- 1/22.4 g/L
 - 2/22.4 g/L
 - 1/4 g/L
 - 4/22.4 g/L
 - 4/4 g/L
18. (#7- 3b)
A sealed container contains 0.20 moles of oxygen gas and 0.10 moles of hydrogen gas. If the temperature is 25C throughout the container, which of the following is true?
- The partial pressures of the two gases are the same.
 - The average kinetic energy of the two gases are the same
 - The molecular masses of the two gases are the same.
 - The total masses of the two gases are the same.
 - The average molecular speeds of the two gases are the same.

19. (#3-4) CO_2 has polar bonds but is gaseous at room temperature. Which explains the reason for this?
- Having a highly electronegative atom makes it more attractive to other molecules of CO_2 therefore it is a gas
 - Room temperature is sufficient energy to separate the liquid into a gas.
 - CO_2 lacks the hydrogen bonding necessary to convert to a liquid at room temperature.
 - CO_2 is symmetrical and is therefore non-polar and this results in a gas at room temperature.

20. (#7-1a) When a substance undergoes a phase change from a liquid to a solid, which of the following will occur?

- Energy will be released by the substance because intermolecular forces are being weakened.
- Energy will be released by the substance because intermolecular forces are being strengthened
- Energy will be absorbed by the substance because intermolecular forces are being weakened
- Energy will be absorbed by the substance because intermolecular forces are being strengthened
- The energy of the substance will not change.



21. (#7-2c) A solution contains equal masses of glucose (molecular mass 180g/mol) and toluene (molecular mass 90g/mol). What is the fraction of the glucose in the solution?

- ~~1/4~~
- ~~1/3~~

- 2/3
- 3/4

180g — 1 mol glucose
90g — 2 mol toluene

1/3

22. (#7-2c) What is the final concentration of Cl^- ion when 250mL of 0.20 M CaCl_2 solution is mixed with 250mL of 0.40 M KCl solution? (assume volumes are additive) (Last Modified 05-14-04)

- .10
- .20
- .30

- .40
- .60

.4 → .4
KCl .4

23. (#7-2b) In the dissolving of solid CaCl_2 in water to form an aqueous solution, bonds in CaCl_2 between

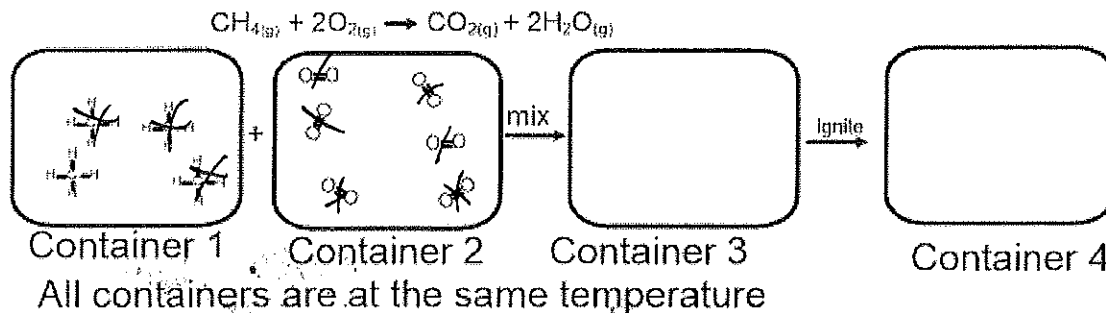
- ions are broken as ion-dipole bonds form
- ions are broken as covalent bonds form
- atoms are broken as covalent bonds form
- molecules are broken as ion-dipole bonds form
- molecules are broken as dipole-dipole bonds form

24. (#7-3c) A balloon occupies a volume of 1.0L when it contains 0.16g of helium at 37C and 1 atm pressure. If helium is added to the balloon until it contains 0.80grams while pressure and temperature are kept constant, what will be the new volume of the balloon?

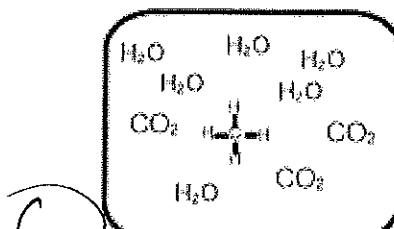
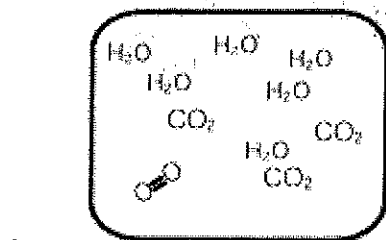
- 0.50 L
- 1.0 L
- 2.0 L

- 4.0 L
- 5.0 L

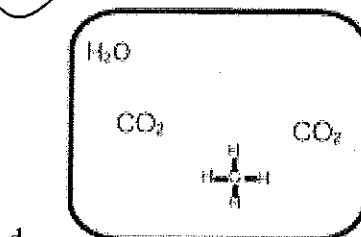
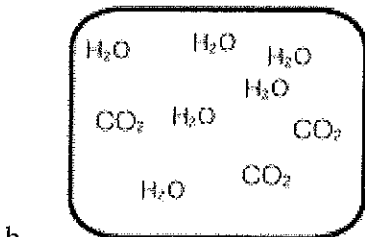
.8g ← .16
x5
PV = nRT
V = $\frac{nRT}{P}$ x5



25. Which of the two initial vessels has the greatest pressure?
- Container 1, due to highest molecular velocity.
 - Container 2, due to highest average kinetic energy
 - Container 1 = Container 2
 - Container 2, due to more collisions per area.
26. If container 1 pressure = 1atm then the pressure in container 3 =
- = 2
 - < 2
 - > 2
 - This is dependent on the limiting reactant.
- Proportion* *Proportion*
27. Which of the following diagrams accurately represents container 4



*3 CO2
6 H2O
1 excess CH4*



Note Coefficients

28. How does the pressure in container 4 compare to container 3
- 4 = 3 due to an equal number of particles
 - 4 > 3 due to an increase in temperature
 - 4 < 3 due to the limiting reactant.
 - 4 > 3 due to the excess reactant
29. (#7-4) What mass of Au is produced when, 0.05 mol of Au_2S_3 is reduced completely with excess H_2 .
- 9.85g
 - 19.7g
 - 24.5g
 - 39.4g
 - 48.9g

Concentration of mass

0.05 mol Au_2S_3 = 0.1 mol Au

1 mol Au = 197g

$\frac{1 \text{ mol Au}}{197 \text{ g}} = \frac{0.1 \text{ Au}}{19.7}$

30. (#7-2c) How many moles of water must be added to 20 moles of ethanol in order to prepare a solution that is 0.25 mole fraction in ethanol? (Mole fraction = moles/total moles)
- a. 5.0
 - b. 15
 - c. 60
 - d. 80
 - e. 75

$$\frac{\text{Moles}}{\text{total moles}} = \text{Mole Fraction}$$

$$\frac{20}{x} = 0.25$$

$$(60 \text{ total})$$

$$x = 80$$

$$\begin{array}{r} \text{But } 80 = \text{total} \\ - 20 \text{ original} \\ \hline 60 \end{array}$$