When the path is blocked, back up and see more of the way.

1. A 250 L vessel is evacuated and then connected to a 50.0 L bulb with compressed nitrogen. The pressure in the combined containers is 1672 mm Hg. If the temperature remained at 20 °C throughout the process, what was the initial pressure in the 50.0 L bulb?

   A. 2.6 atm  
   B. 13.2 atm  
   C. 4.4 atm  
   D. 17.6 atm  
   E. 11.0 atm

2. The density of a gas at 1.0 atm and 298 K is 1.23 g/L. What is its molecular formula?

   A. CO₂  
   B. CH₄  
   C. NH₃  
   D. NO  
   E. NO₂
3. What is the total number of molecules that comprise one breath of air with a volume of 1.5 L at body temperature (37 °C) and a pressure of 0.987 atm?

A. $3.50 \times 10^{22}$
B. $9.67 \times 10^{26}$
C. $7.01 \times 10^{22}$
D. $4.50 \times 10^{20}$
E. $2.94 \times 10^{23}$

4. What is the mole fraction of urea (MW = 60.0 g/mol) in a solution prepared by dissolving 16 g urea in 39 g water?

A. 0.58
B. 0.37
C. 0.11
D. 0.13
E. 9.1
5. What is the normal freezing point of the sample?

   A. 190 K
   B. 265 K
   C. 300 K
   D. 360 K
   E. It is not shown on this part of the phase diagram.

6. What phase is present at $T = 190$ K, $P = 1$ atm?

   A. gas only
   B. liquid only
   C. solid only
   D. gas and liquid
   E. solid and liquid
7. A gas mixture of Ne and Ar has a total pressure of 4.00 atm and contains 16.0 mol of gas. If the partial pressure of Ne is 2.75 atm, how many moles of Ar are in the mixture?

A. 11.0  
B. 5.00  
C. 6.75  
D. 9.25  
E. 12.0

8. A sample of oxygen gas (O₂) was found to effuse at a rate equal to three times that of an unknown gas. What is the molecular weight of the unknown gas?

A. 288 g/mol  
B. 144 g/mol  
C. 96 g/mol  
D. 55 g/mol  
E. 10.7 g/mol
9. Two moles of CO are in a 10.0 L flask at 298 K. Some He is added to the flask at constant T until the total pressure is 8.5 atm. What is the partial pressure of the CO in the flask after the He has been added?

A. 0.85 atm  
B. 3.6 atm  
C. 4.3 atm  
D. 4.9 atm  
E. 8.5 atm

10. Which of the following gases contribute significantly to the greenhouse effect?

   i. Ar  
   ii. He  
   iii. CO₂  
   iv. H₂O

A. i and iv only  
B. iii only  
C. iv only  
D. iii and iv only  
E. i and ii only
The data in the table describes the conditions of the gases in the figure. Use this data to answer the following two questions.

<table>
<thead>
<tr>
<th>Volume</th>
<th>2.00 L</th>
<th>2.00 L</th>
<th>1.00 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>1.0 atm</td>
<td>2.0 atm</td>
<td>1.5 atm</td>
</tr>
<tr>
<td>Temperature</td>
<td>25 °C</td>
<td>50 °C</td>
<td>50 °C</td>
</tr>
</tbody>
</table>

11. Which gas has the greatest average kinetic energy?
   A. $\text{N}_2$
   B. $\text{Ne}$
   C. $\text{H}_2$
   D. $\text{Ne}$ and $\text{H}_2$ have the same and greatest average kinetic energy.
   E. $\text{N}_2$ and $\text{Ne}$ have the same and greatest average kinetic energy.

12. Rank the gases in order of increasing rms speed.
   A. $\text{H}_2 > \text{Ne} > \text{N}_2$
   B. $\text{Ne} > \text{N}_2 > \text{H}_2$
   C. $\text{H}_2 = \text{Ne} > \text{N}_2$
   D. $\text{Ne} > \text{H}_2 > \text{N}_2$
   E. $\text{H}_2 > \text{Ne} = \text{N}_2$

Go on to the next page
13. These distributions were obtained for five different gases at the same temperature. Which of the statements is/are true?

i. The gases have the same average kinetic energy.

ii. H₂ has the greatest percentage of molecules that move at high molecular speeds.

iii. The rms speed of He is greater than the rms speed of O₂.

A. i only
B. ii only
C. i and ii only
D. i and iii only
E. i, ii and iii.
14. The molecule of $\text{N}_2(\text{g})$ has a $\text{N}≡\text{N}$ bond dissociation energy of 942 kJ/mol. What is the maximum wavelength of photons that can rupture this bond?

A. 254 nm  
B. 57 nm  
C. 0.4 nm  
D. 127 nm  
E. 353 nm

15. What type of intermolecular force(s) are important when a nonpolar substance dissolves in another nonpolar substance?

i. Hydrogen bonding  
ii. Dipole dipole  
iii. London dispersion

A. i  
B. ii  
C. iii  
D. i and iii  
E. None of the above
16. The temperature of 50.0 g of heptane \((C_7H_{16})\) increases by 5.82 °C when 300 J of heat is added to the sample. What is the **molar** heat capacity of heptane?

A. 2.03 J/(mol·K)  
B. 97.0 J/(mol·K)  
C. 88.7 J/(mol·K)  
D. 103 J/(mol·K)  
E. 8.87 J/(mol·K)

17. Which of the following is/are **false**?

(i) Increasing the concentration of a nonvolatile solute in water decreases the vapor pressure.
(ii) Increasing the concentration of a nonvolatile solute in water decreases the freezing point.
(iii) Increasing the concentration of a nonvolatile solute in water decreases the boiling point.
(iv) Increasing the concentration of a nonvolatile solute in water increases the osmotic pressure.

A. i and iii  
B. iii only  
C. i, ii, and iii  
D. i , iv  
E. i only
18. Which of the following substances is a non-electrolyte?

A. benzene (C₆H₆)
B. H₂SO₄
C. NH₃
D. NaOH
E. FeCl₃

19. What amount of heat is required to convert an 18.0 g sample of ice at 273 K into steam at 100 °C? The specific heat of ice, water, and steam are 2.03 J/g·K, 4.18 J/g·K, and 1.84 J/g·K, respectively. The \( \Delta H_{\text{fus}} \) is 6.01 kJ/mol and the \( \Delta H_{\text{vap}} \) is 40.67 kJ/mol.

A. 7570 kJ/mol
B. 54.2 kJ/mol
C. 50.3 kJ/mol
D. 3700 kJ/mol
E. 1250 kJ/mol
20. The process indicated by the arrow in the phase diagram below is a pressure increase at constant temperature. What phase change occurs in this process (I → F) and is this phase change exothermic or endothermic?

A. condensation: endothermic
B. melting: exothermic
C. evaporation: endothermic
D. condensation: exothermic
E. sublimation: endothermic
21. Which liquid would be the most volatile?

A

B

C

D

E

22. Which of the following statements regarding solubility of O₂ gas in a solvent in a closed container is correct?

A. Solubility increases with increasing O₂ pressure and increasing temperature.
B. Solubility increases with increasing O₂ pressure and decreasing temperature.
C. Solubility increases with decreasing O₂ pressure and increasing temperature.
D. Solubility increases with decreasing O₂ pressure and decreasing temperature.
E. Solubility increases with increasing O₂ pressure and does not change with temperature.
23. Which one of the following substances is most likely to be soluble in water?

A  \[\text{H} \quad 	ext{H} \quad \text{H} \]
\[\text{H} \quad \text{C} \quad \text{C} \quad \text{OH} \]
\[\text{OH} \quad \text{H} \]

B  \[\text{H} \]
\[\text{Cl} \quad \text{C} \quad \text{Cl} \]
\[\text{Cl} \quad \text{Cl} \]

C  \[\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{O} \]

D  \[\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \]

E  \[\text{Cl} \quad \text{C} \quad \text{Cl} \]
\[\text{Cl} \quad \text{Cl} \]


24. A 1.35 m aqueous solution of substance X had a normal boiling point of 101.4°C. Which one of the following could be X? The boiling point elevation constant for water is 0.52 °C/m.

A. CH₃CH₂OH  
B. C₆H₁₂O₆  
C. Na₃PO₄  
D. KCl  
E. CaCl₂

25. A sample of glycerin (C₃H₈O₃), which is found to be a nonelectrolyte, has a density of 0.56 g/mL at 25 °C. Calculate the vapor pressure at 25 °C of a solution made by adding 25.0 mL of the sample to 500.0 mL of water which has a density of 1.00 g/mL. The vapor pressure of pure water at 25 °C is 23.8 torr.

A. 0.000170 atm  
B. 0.129 atm  
C. 0.0380 atm  
D. 0.0311 atm  
E. 0.0567 atm
26. What is the correct order of the freezing points for the following aqueous solutions?

I. 0.010 m BaCl₂
II. 0.010 m C₆H₁₂O₆
III. 0.020 m KBr

A. III > II > I
B. III > I > II
C. I > III > II
D. II > I > III
E. I > II > III

27. What is the concentration of the chloride ions in a solution formed by adding 3.5 grams of NaCl to 50.0 mL of a 0.50 M CaCl₂ solution?

A. 1.2 M
B. 0.50 M
C. 2.2 M
D. 0.060 M
E. 0.025 M
28. Each curve shown below corresponds to one mole of the same gas at different temperatures. Which curve corresponds to the gas sample at the lowest temperature?

A. 1  
B. 2  
C. 3  
D. 4  
E. There is insufficient information to decide.
FORM A
1. B
2. D
3. A
4. C
5. B
6. C
7. B
8. A
9. D
10. D
11. D
12. A
13. E
14. D
15. C
16. D
17. B
18. A
19. B
20. D
21. A
22. B
23. A
24. D
25. D
26. D
27. C
28. A