1. The cylinder shown below is filled with enough N\textsubscript{2} gas at 25 °C to reach a volume of 0.100 L under 750 torr of atmospheric pressure. A mountaineer carries the cylinder to the top of Mt. Everest where the temperature and pressure are –30 °C and 210 torr. What is the final volume of N\textsubscript{2} gas in the cylinder atop the mountain?

A. 0.027 L  
B. 0.137 L  
C. 0.235 L  
D. 0.291 L  
E. 0.358 L

2. A sample of gas is placed in an open-ended Hg manometer as shown below. The difference in the height of the mercury between the two arms, h, is 27 mm. The external pressure is 600 torr. What is the pressure of the gas?

A. 787 torr  
B. 627 torr  
C. 573 torr  
D. 760 torr  
E. 488 torr

3. The mass of a flask with a 1.00 L volume that is evacuated to a pressure of 0.00 atm is found to be 92.01 g. After introduction of an unknown ideal gas with a pressure of 3.00 atm and temperature of 27 °C, the mass of the flask and gas are found to be 97.37 g. Identify the unknown gas.

A. CO\textsubscript{2}  
B. N\textsubscript{2}  
C. Ne  
D. Kr  
E. Xe

4. Which one of the following gases is most likely to deviate from the behavior of an ideal gas?

A. O\textsubscript{2}  
B. CH\textsubscript{4}  
C. N\textsubscript{2}  
D. SF\textsubscript{6}  
E. C\textsubscript{2}H\textsubscript{6}
5. What mass of Na₂SO₄ is needed to prepare 250 mL of a solution having a sodium ion concentration of 0.250 M?

A. 1.11 g  
B. 2.22 g  
C. 3.68 g  
D. 5.82 g  
E. 4.44 g

6. Identify the substance that has the strongest dipole-dipole intermolecular forces.

A.  
B.  
C.  
D.  
E.  

7. For the following phase diagram, which of the following is true?

A. The substance at point A is a pure liquid.  
B. The substance at point D is comprised of only solid and liquid.  
C. The substance going from point B to point C will undergo melting.  
D. The substance going from point J to point H will undergo freezing.  
E. The substance going from point E to point F will undergo evaporation and then condensation.
8. Which of the following changes in an ideal gas will result in an increase in pressure?

(i) Increasing the speed of the molecules in the gas at fixed V and n.
(ii) Decreasing the number of molecules in the gas at fixed V and T.
(iii) Decreasing the volume of the gas at fixed T and n.

A. only i  
B. only iii  
C. i and iii  
D. ii and iii  
E. i, ii, and iii

9. Consider a balloon at STP filled with air, which is 78% N₂, 21% O₂, and 1% Ar. Which of the following statements are correct:

   i) All three gases have the same average kinetic energy.
   ii) All three gases have the same rms speed.
   iii) All three gases have the same partial pressures.

A. i only  
B. ii only  
C. iii only  
D. i and iii only  
E. ii and iii only

The following mixture of gases is in the same container under the conditions given below. Use this information to answer the next two questions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Xₐ</th>
</tr>
</thead>
<tbody>
<tr>
<td>T = 25.0 °C</td>
<td>He</td>
<td>????</td>
<td></td>
</tr>
<tr>
<td>V = 15.0 L</td>
<td>Ar</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>P = 1.30 atm</td>
<td>Kr</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N₂</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

10. What is the partial pressure of He in the container?

A. 0.130 atm  
B. 0.195 atm  
C. 0.325 atm  
D. 0.975 atm  
E. 1.30 atm

11. Which one of the gases in this mixture contributes most to the total mass in the flask?

A. He  
B. Ar  
C. Kr  
D. N₂  
E. CO₂
12. A heating curve for one mole of substance A is shown below. What is the molar heat capacity of liquid A?

![Heating curve graph]

A. 20.0 kJ/mol·K  
B. 1.00 kJ/mol·K  
C. 500 J/mol·K  
D. 200 J/mol·K  
E. 120 J/mol·K

13. Which of the following compounds has the highest vapor pressure at 0 °C?

![Chemical structures]

A.  
B.  
C.  
D.  
E.  

14. To what volume should you dilute 133 mL of a 7.90 M CuCl₂ solution so that 51.5 mL of the diluted solution contains 4.49 g CuCl₂?

A. 1315 mL  
B. 1620 mL  
C. 595 mL  
D. 185 mL  
E. 867 mL

15. Which of the following are strong electrolytes?

i. CH₃OH  
ii. HCl  
iii. CH₃COOH

A. i only  
B. ii only  
C. iii only  
D. i and ii  
E. ii and iii
16. A sample of potassium nitrate (50.0 g) is dissolved in 100 g of water at 95 °C, with precautions taken to avoid evaporation of any water. The solution is cooled to 15.0 °C and no precipitate is observed. This solution is _________.

A. in equilibrium  
B. superfluid  
C. saturated  
D. unsaturated  
E. supersaturated

17. Which of the following compounds would be least soluble in hexane?

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \quad \text{E} \]

18. The solubility of N\(_2\) in water is \(8.21 \times 10^{-4}\) mol/L at 0 °C at a total pressure of 760 torr. Recalling that the mole fraction of N\(_2\) in air at sea level is 0.781, calculate the Henry’s law constant for N\(_2\).

A. \(1.05 \times 10^{-3}\) mol/L·atm  
B. \(1.08 \times 10^{-6}\) mol/L·atm  
C. \(1.08 \times 10^{-3}\) mol/L·atm  
D. \(7.81 \times 10^{-5}\) mol/L·atm  
E. \(1.00 \times 10^{-4}\) mol/L·atm

19. A 0.102 g sample of an unknown compound dissolved in 100 mL of water has an osmotic pressure of 28.1 mm Hg at 20 °C. The solution does not conduct electricity. Calculate the molar mass of the compound.

A. 663 g/mol  
B. 0.875 g/mol  
C. 1.15 g/mol  
D. 727 g/mol  
E. 110 g/mol
20. An engineer needs to reduce the amount of dissolved $\text{O}_2(g)$ from a solution in order to avoid an unwanted oxidation reaction. What action could the engineer take to lower the concentration of dissolved oxygen?

i. Increase the total pressure to squeeze the gas out of solution.
ii. Increase the temperature of the solution.
iii. Decrease the temperature.

A. i only
B. ii only
C. i and ii only
D. ii and iii only
E. i, ii, and iii

21. Which one of the following aqueous solutions will have the highest vapor pressure?

A. 0.10 M KCl(aq)
B. 0.10 M BaCl$_2$(aq)
C. 0.10 M Ca(NO$_3$)$_2$(aq)
D. 0.10 M K$_2$SO$_4$ (aq)
E. 0.20 M KNO$_3$(aq)

22. Rank the following liquids according to their viscosity, starting with the least viscous.

A. \begin{align*}
\text{O} & \quad \text{HO} \\
\text{HO} & \quad \text{OH} \\
\text{OH} & \quad \text{HO}
\end{align*}

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

23. If an empty aluminum can weighs 13.49 g, how much energy does it take to completely melt 12 cans that are initially at 20 °C? (Aluminum melts at 660 °C.)

\[ \text{C (s)} = 24.2 \text{ J/mol-°C} \quad \Delta H_{\text{fus}} = 10.71 \text{ kJ/mol} \]
\[ \text{C (l)} = 29.3 \text{ J/mol-°C} \quad \Delta H_{\text{vap}} = 294.0 \text{ kJ/mol} \]

A. 157.19 kJ
B. 64.26 kJ
C. 92992 kJ
D. 26.20 kJ
E. 15.49 kJ

Go on to the next page
24. If 50 mL of 10 mM NaCl(aq) is combined with a 40 mL of 5.0 mM BaCl\(_2\)(aq), what is the new concentration of chloride ions?

A. 5.0 mM
B. 10 mM
C. 20 mM
D. 40 mM
E. 90 mM

25. A 1.32 \(m\) aqueous solution of compound \(Y\) had a boiling point of 101.4°C. Which of the following could be compound \(Y\)? \((K_b\) for water is 0.53°C/m.)

A. CH\(_3\)OH
B. C\(_6\)H\(_{12}\)O\(_6\)
C. Na\(_3\)PO\(_4\)
D. KCl
E. MgCl\(_2\)

26. An unknown gas effuses at a rate 1.62 times \textbf{slower} than O\(_2\). Which one of the following could be the identity of the gas?

A. H\(_2\)
B. Ar
C. Xe
D. C\(_4\)H\(_{10}\)
E. Kr

27. Rank the following in order of increasing boiling point:

\[ \begin{align*}
\text{i} & \quad \text{ii} & \quad \text{iii} \\
\text{A. i < ii < iii} & \quad \text{B. ii < i < iii} & \quad \text{C. i < iii < ii} \\
\text{D. ii < iii < i} & \quad \text{E. iii < i < ii} \\
\end{align*} \]
28. The root mean square speed of CH₄ gas molecules at a particular temperature is found to be 910 m/s. Identify the curve below that describes the root mean square speed distribution of SF₆ gas molecules at the same temperature.

A. curve I
B. curve II
C. curve III
D. curve IV
E. insufficient information is given to answer the question.

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End of Exam