1. If a constant number of moles of gas is at a pressure of 1.35 atm and has a volume of 23.8 L at a temperature of 205.1 K then what is the final volume of the gas if the pressure changes to 2.84 atm and the temperature rises to 233.4 K?

A. 0.18 L  
B. 9.9 L  
C. 12.9 L  
D. 44.0 L  
E. 57.0 L

2. Each of these will be a liquid at 25 °C. Which one of these will have the greatest surface tension at that temperature?

A.  
B.  
C.  
D.  
E.  
3. The solubility of nitrogen gas at 25°C and a nitrogen pressure of 522 torr is \(4.7 \times 10^{-4}\) mol/L. What is the value of the Henry's Law constant?

A. \(6.8 \times 10^{-4}\) mol L\(^{-1}\) atm\(^{-1}\)
B. \(4.7 \times 10^{-4}\) mol L\(^{-1}\) atm\(^{-1}\)
C. \(3.2 \times 10^{-4}\) mol L\(^{-1}\) atm\(^{-1}\)
D. \(9.0 \times 10^{-7}\) mol L\(^{-1}\) atm\(^{-1}\)
E. \(1.5 \times 10^{3}\) mol L\(^{-1}\) atm\(^{-1}\)

4. Which of the following properties indicates the presence of strong intermolecular forces in a liquid?

A. a low viscosity
B. a low heat of vaporization
C. a low boiling temperature
D. a low vapor pressure
E. all of the answers here

5. Determine the molar mass of Freon-11 gas if a sample weighing 0.597 g occupies 100.0 cm\(^3\) at 95°C, and 1000.0 mm Hg

A. 0.19 g/mol
B. 35.3 g/mol
C. 70.9 g/mol
D. 137 g/mol
E. 384 g/mol
6. The three samples of gas molecules shown below schematically are all at the same temperature, in the same volume container. Rank them in order of increasing total pressure. (Assume the gases behave ideally.)

\[ \text{O} = \text{Ne} \quad = \quad \text{O}_2 \]

\( i \) \hspace{2cm} \( ii \) \hspace{2cm} \( iii \)

A. \( i < ii < iii \)  
B. \( iii < i < ii \)  
C. \( ii < i = iii \)  
D. \( i < iii < ii \)  
E. \( iii = i < ii \)

7. What mass of lithium phosphate (\( \text{Li}_3\text{PO}_4 \)) is needed to prepare 500 mL of a solution having a lithium ion concentration of 0.125 \( M \)?

A. 2.41 g  
B. 6.75 g  
C. 10.1 g  
D. 19.3 g  
E. 30.4 g
Use the plot above to answer this question.

8. What is the boiling point of substance B at 400 torr?

   A. 18 °C
   B. 34 °C
   C. 63 °C
   D. 78 °C
   E. 83 °C
9. What is the *distinguishing characteristic* of all electrolyte solutions?

   A. Electrolytes contain molecules.
   B. Electrolytes conduct electricity.
   C. Electrolytes react with other solutions.
   D. Electrolytes always contain acids.
   E. Electrolytes conduct heat.

10. Which of these compounds is a *weak electrolyte*?

    i. HCl      ii. NH₃      iii. CH₃COOH      iv. C₆H₁₂O₆ (glucose)

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

11. At what temperature would a molecule of $^4$He have a root mean square speed equal to the speed of sound, 331.3 m/s, at 1 atm?

    A. 17.6 K
    B. 253 K
    C. 273 K
    D. 293 K
    E. 17600 K
12. If equal masses of O\textsubscript{2}(g) and HBr(g) are in separate containers of equal volume and temperature, which one of the following statements is true?

A. The pressure in the O\textsubscript{2} container is greater than that in the HBr container.

B. There are more HBr molecules than O\textsubscript{2} molecules.

C. The average velocity of the O\textsubscript{2} molecules is less than that of the HBr molecules.

D. The average kinetic energy of HBr molecules is greater than that of O\textsubscript{2} molecules.

E. The pressures of both gases are the same.

13. A mixture of oxygen and nitrogen with a total pressure of 10 atm is contained in a 5 L vessel at 400 °C. If the pressure ratio of oxygen-to-nitrogen is 3:2, what is the mole ratio of the gases when the temperature is decreased to 20 °C at constant V?

A. 0.67

B. 1.0

C. 1.5

D. 2.3

E. 20
14. The plot shows the distribution of speeds of 3 different gases at the same temperature. Which of the following statements is(are) true?

i. C corresponds to the gas sample with the greatest average speed.
ii. The molecular weight of A is greater than B.
iii. C corresponds to the gas with the greatest average kinetic energy.

A. i only
B. ii only
C. iii only
D. i and ii
E. i and iii
15. What can you tell from these pictures about the relationship between the cohesive and adhesive forces in the systems depicted by figures A and B?

![Diagram](image)

1. In figure A, the adhesive forces between the liquid and the capillary walls are greater than the cohesive forces within the liquid.
2. In figure B, the adhesive forces between the liquid and the capillary walls are greater than the cohesive forces within the liquid.
3. In figure A, the adhesive forces between the liquid and the capillary walls are less than the cohesive forces within the liquid.
4. In figure B, the adhesive forces between the liquid and the capillary walls are less than the cohesive forces within the liquid.

A. Statements 1 and 2 are true.
B. Statements 1 and 3 are true.
C. Statements 1 and 4 are true.
D. Statements 2 and 3 are true.
E. Statements 2 and 4 are true.

16. Which of these transitions will release the greatest amount of energy?

A. melting a mole of water
B. boiling a mole of water
C. subliming a mole of water
D. freezing a mole of water
E. Data is needed (heats of the transitions) to be able to answer this.
17. If an aluminum can weighs 13.49 g, how much energy does it take to heat 2 cans from 20 °C to 700 °C if aluminum melts at 660 °C?

\[C (s) = 24.2 \text{ J/mol} \cdot ^{\circ}\text{C}\]
\[C (\ell) = 29.3 \text{ J/mol} \cdot ^{\circ}\text{C}\]
\[\Delta H_{\text{fus}} = 10.71 \text{ kJ/mol}\]
\[\Delta H_{\text{vap}} = 294.0 \text{ kJ/mol}\]

A. 4.16 kJ  
B. 8.33 kJ  
C. 13.7 kJ  
D. 16.7 kJ  
E. 27.4 kJ

18. What is the molality (m) of a 36.45% (by weight) solution of HCl in water?

A. 0.0157 m  
B. 0.0274 m  
C. 1.00 m  
D. 15.74 m  
E. 63.55 m
19. For the following phase diagram, which of the following is true?

A. A substance going from point C to B undergoes a pressure change.
B. Point G is the triple point.
C. Point D is the critical point.
D. A substance at point D is all one phase.
E. A substance at point G is all one phase.

20. Which of the following compounds is most soluble in CCl₄?

A. NaCl
B. H₂O
C. NaOH
D. C₈H₁₈
E. None of these
21. From the following list of aqueous solutions and water, select the one with the highest boiling point.

A. 1.0 M KNO₃  
B. 0.75 M NaCl  
C. 0.75 M CuCl₂  
D. 2.0 M sucrose  
E. pure water

22. Rank the following gases based upon most to least ideal at STP.

\[
\text{NF}_3 \quad \text{Ne} \quad \text{O}_2 \quad \text{CCl}_2\text{F}_2
\]

Most ideal \hspace{1cm} least ideal

A. Ne > CCl₂F₂ > O₂ > NF₃  
B. CCl₂F₂ > O₂ > NF₃ > Ne  
C. Ne > O₂ > NF₃ > CCl₂F₂  
D. Ne > CCl₂F₂ > NF₃ > O₂  
E. CCl₂F₂ > Ne > O₂ > NF₃

23. A 50.0 mL sample of 0.436 M NH₄NO₃ is mixed with 200mL of 0.320 M NaNO₃. What is the nitrate ion concentration in the resulting solution?

A. \(8.72 \times 10^{-2}\) M  
B. 0.256 M  
C. 0.343 M  
D. 0.756 M  
E. 0.858 M
24. Hexachlorophene (a nonelectrolyte) is used as a disinfectant in germicidal soaps. What mass of hexachlorophene (M = 406.9 g/mol) must be added to 125 g of chloroform (CHCl₃) to give a solution with a boiling point of 62.60°C?

\[ K_b = 3.63°C/m, \text{ boiling point of pure chloroform} = 61.70°C. \]

A. 12.6 g  
B. 17.2 g  
C. 31.0 g  
D. 34.4 g  
E. 101 g

25. Calculate the molecular weight of a small protein (a non-electrolyte) if a 200 mg sample dissolved in 100 mL of water has an osmotic pressure of 9.8 mm Hg at 25.0 °C

A. \( 3.5 \times 10^3 \) g/mol  
B. \( 3.8 \times 10^3 \) g/mol  
C. \( 4.0 \times 10^3 \) g/mol  
D. \( 4.5 \times 10^3 \) g/mol  
E. \( 4.5 \times 10^4 \) g/mol
26. Based on the data in the figure above, which salts could be saturated solutions, if 40 g of the salt is mixed with 100 g of water at 20 °C?

A. only KClO₃  
B. only NaNO₃  
C. KCl and NaCl  
D. NaNO₃ and Pb(NO₃)₂  
E. KCl, NaCl, and KClO₃
27. What pressure would be required for helium to have the same density as oxygen gas at 25 °C and 1 atm?

A. 2.0 atm  
B. 4.0 atm  
C. 6.0 atm  
D. 8.0 atm  
E. 10.0 atm

28. If 1.00 kg of stainless steel at 100 °C is dropped into 1.00 kg of H₂O at 20 °C, what will the final temperature of the system be?

stainless steel  \( C \) (s) = 0.5 J/g-°C  
H₂O  \( C \) (l) = 4.184 J/g-°C

A. 28.5 °C  
B. 34.6 °C  
C. 48.9 °C  
D. 55.3 °C  
E. 60.0 °C

END OF EXAM
FORM A
1. C
2. E
3. A
4. D
5. D
6. B
7. A
8. C
9. B
10. D
11. A
12. A
13. C
14. D
15. D
16. D
17. E
18. D
19. E
20. D
21. C
22. C
23. C
24. A
25. B
26. E
27. D
28. A