1. The pressure of a certain gas is measured to be $2.039 \times 10^3$ Pa. What is this pressure expressed in units of mmHg? (1 atm = 1.01325 x10^5 Pa and 760mmHg = 1 atm)
   a) $1.550 \times 10^5$ mmHg
   b) 15.29 mmHg
   c) $2.648 \times 10^{-5}$ mmHg
   d) $3.777 \times 10^4$ mmHg
   e) $6.539 \times 10^{-2}$ mmHg

2. Absolute zero is the temperature at which
   a) gaseous helium liquefies.
   b) a straight-line graph of $P$ versus $1/V$ intersects the $1/V$ axis.
   c) a straight-line graph of $V$ versus $1/P$ intersects the $1/P$ axis.
   d) a graph of $P$ versus $V$ at constant $T$ intersects the $V$ axis.
   e) a straight-line graph of $V$ versus $T$ intersects the $T$ axis.

3. Which of the following statements, concerning equal volumes of the gases dinitrogen monoxide, N$_2$O, and propane, C$_3$H$_8$, at the same temperature and pressure, is incorrect?
   a) They have the same density.
   b) They have the same number of moles.
   c) They have the same number of molecules.
   d) They have the same number of atoms.
   e) They have the same absolute temperature.

4. At 727.5 mmHg and 57.1°C, a 4.55-L sample of a hydrocarbon gas has a mass of 6.76 g. What is the formula of the gas?
   a) C$_3$H$_8$
   b) C$_3$H$_6$
   c) C$_2$H$_2$
   d) C$_2$H$_4$
   e) C$_2$H$_6$

5. The following equation represents the oxidation of ammonia, NH$_3$.
   $$4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g)$$
   At the same temperature and pressure, what is the maximum volume of nitrogen monoxide that can be obtained from $7.22 \times 10^2$ L of ammonia and $7.22 \times 10^2$ L of oxygen?
   a) $1.44 \times 10^3$ L
   b) $3.21 \times 10^2$ L
   c) $7.22 \times 10^2$ L
   d) $5.78 \times 10^2$ L
   e) $1.62 \times 10^3$ L
6. A sample of oxygen is collected over water at a total pressure of 616.8 mmHg at 30°C. The vapor pressure of water at 30°C is 31.8 mmHg. The partial pressure of the O₂ is
   a) 0.8116 atm.
   b) 0.8534 atm.
   c) 0.7697 atm.
   d) 1.110 atm.
   e) 0.9010 atm.

7. Which statement is inconsistent with the kinetic theory of an ideal gas?
   a) The forces of repulsion between gas molecules are very weak or negligible.
   b) Most of the volume occupied by a gas is empty space.
   c) The collisions between gas molecules are inelastic.
   d) The average kinetic energy of a gas is proportional to the absolute temperature.
   e) Gas molecules move in a straight line between collisions.

8. Calculate the root-mean-square velocity for the O₂ molecules in a sample of O₂ gas at 22.5°C. (R = 8.3145 J/Kmol)
   a) 132.4 m/s
   b) 15.18 m/s
   c) 479.9 m/s
   d) 277.1 m/s
   e) 9.140 × 10^{26} m/s

9. Which of the following gases will have the slowest rate of effusion at constant temperature?
   a) CF₄
   b) F₂
   c) H₂
   d) Ne
   e) SO₃

10. In the Van der Waals equation,
    \[ P + \frac{an^2}{V^2} (V - nb) = nRT \]
    the effect of intermolecular forces is accounted for by
    a) a
    b) P
    c) V
    d) b
    e) T

11. The normal boiling point of a liquid is
    a) the only temperature at which there can be equilibrium between the liquid and gas states.
    b) the temperature above which the substance cannot exist as a liquid regardless of the pressure.
    c) the temperature at which the amounts of liquid and gas are equal.
    d) the temperature at which the vapor pressure equals 760 mmHg.
    e) the temperature at which all three phases are in equilibrium.
12. A particular compound has an enthalpy of vaporization of 28900 J/mol. At 278 K it has a vapor pressure of 103 mmHg. What is its vapor pressure at 309 K? \((R = 8.31 \text{ J/(K} \cdot \text{mol)})\)
   a) 29.4 mmHg
   b) 194 mmHg
   c) 107 mmHg
   d) 99.5 mmHg
   e) 361 mmHg

13. Below is a phase diagram for a substance.

   ![Phase Diagram](image)

   What is the name for point X on the diagram?
   a) normal boiling point.
   b) boiling point.
   c) melting point.
   d) critical point.
   e) triple point.

14. A solid has a very high melting point, is hard, and in the molten state is a non-conductor. The solid is most likely
   a) a molecular solid.
   b) a metallic solid.
   c) a covalent network solid.
   d) an ionic solid.
   e) an amorphous solid.

15. A metal crystallizes in a face-centered cubic lattice. The radius of the atom is 196 pm and the density of the element is 1.55 g/cm\(^3\). How many atoms are there per unit cell?
   a) 1
   b) 2
   c) 4
   d) 6
   e) 8
16. When a solid undergoes a phase change to a gas, the process is called
   a) condensation.
   b) melting.
   c) fusion.
   d) sublimation.
   e) vaporization.

   From a consideration of the phase diagram below, a change from point M to point N corresponds to
   a) sublimation.
   b) condensation.
   c) evaporation.
   d) freezing.
   e) liquefaction.

17. Below is a phase diagram for a substance.

   Which line represents the melting-point curve of the substance?
   a) M-N
   b) R-X
   c) X-Z
   d) S-X
   e) S-Z
18. Which one of the following decreases as the strength of the attractive intermolecular forces increases?
   a) The heat of vaporization.
   b) The normal boiling temperature.
   c) The extent of deviations from the ideal gas law.
   d) The sublimation temperature of a solid.
   e) The vapor pressure of a liquid.

19. Which of the following indicates the existence of strong intermolecular forces of attraction in a liquid?
   a) a very low boiling point
   b) a very low vapor pressure
   c) a very low critical temperature
   d) a very low viscosity
   e) a very low enthalpy of vaporization

20. What is the maximum number of hydrogen bonds in which a water molecule could participate?
   a) 2
   b) 3
   c) 4
   d) 5
   e) 6

21. The strongest intermolecular forces present in a sample of pure I₂ are
   a) metallic bonds.
   b) dipole–dipole forces.
   c) covalent bonds.
   d) London forces.
   e) covalent network bonds.

22. Which of the following is the strongest intermolecular force present in dry ice, CO₂(s)?
   a) London forces
   b) covalent bonding
   c) ionic bonding
   d) metallic bonding
   e) hydrogen bonding

23. Which of the following is not a covalent network solid?
   a) silicon carbide
   b) quartz
   c) iron
   d) diamond
   e) graphite

24. A certain solid substance that is very hard, has a high melting point, and is nonconducting unless melted is most likely to be:
   a) I₂
   b) NaCl
   c) CO₂
   d) H₂O
   e) Cu
25. How many atoms are there in a body-centered cubic unit cell of chromium?
   a) 1.
   b) 2.
   c) 4.
   d) 6.
   e) 8.

26. A metal crystallizes in a face-centered cubic lattice. The radius of the atom is 196 pm and the density of the element is 1.55 g/cm³. How many atoms are there per unit cell?
   a) 1
   b) 2
   c) 4
   d) 6
   e) 8

27. The metal cesium crystallizes in a body-centered cubic lattice. If the density of cesium is 1.88 g/cm³, what is the unit cell volume?
   a) $1.17 \times 10^8$ pm³
   b) $2.35 \times 10^7$ pm³
   c) $2.35 \times 10^9$ pm³
   d) $4.70 \times 10^8$ pm³
   e) $1.77 \times 10^6$ pm³

28. In a certain mountain range, water boils at 92°C. What is the atmospheric pressure under these conditions? The enthalpy of vaporization of water at 100°C is 40.7 kJ/mol. ($R = 8.31$ J/(K·mol))
   a) 570 mmHg
   b) 1010 mmHg
   c) 243 mmHg
   d) 237 mmHg
   e) 2380 mmHg

29. The following volume-temperature plots were made at different values of constant pressure while the number of moles of gas in each experiment remained the same. Which plot represents measurements at the highest pressure?

![Diagram](attachment:image.png)

   a) A
   b) B
   c) C
   d) D
   e) They are all at the same pressure.
30. What is the pressure of a 23.2-L gas sample containing 4.76 mol of gas at 42.0°C? \( (R = 0.0821 \text{ L} \cdot \text{atm}/(\text{K} \cdot \text{mol}), 1 \text{ atm} = 760 \text{ mmHg}) \)

a) 5.31 mmHg  
b) \(5.38 \times 10^2\) mmHg  
c) \(4.03 \times 10^3\) mmHg  
d) \(6.98 \times 10^{-3}\) mmHg  
e) \(1.43 \times 10^2\) mmHg