Answers to Unit 4 Review: Gases

1. Solid: fixed shape, incompressible. Liquid: takes shape of container, incompressible. Gas: expands to fill container, compressible.
2. Vibrational (solids, liquids, gas molecules), rotational (liquid, gas), translational (liquid, gas).
3. a) The fastest molecules in a liquid leave the surface. This lowers the <u>average</u> kinetic energy (energy of movement). Recall average kinetic energy = temperature.
   b) gases have large spaces between molecules.
   c) Pressure is caused by collisions of molecules against the side of a container. A high temp. causes molecules to move faster. The # of collisions and their strength increases.

4. Gas molecules move very fast (at the speed of a bullet). Yet, they will not diffuse at this speed because other molecules get in the way. At a high pressure, the rate of diffusion slows down because more molecules are in the way.
5. STP: standard temperature and pressure (0°C, 101.3 kPa). SATP: standard ambient temperature and pressure (25°C, 100 kPa).
6. 360 kPa = 3.55 atm = 27<u>0</u>0 mm Hg
7. See Charles's Law handout (slide 4). The most important point is absolute zero (0 K). At this point, ideal gases have zero volume. In reality, all gases have some volume at 0 K; the space between molecules may approach zero, but molecules themselves provide some volume.

8. 200 K = -73°C, 30°C = 303 K, 0 K = -273°C
9. Charles': $V_1/T_1 = V_2/T_2$
   Boyles: $P_1V_1 = P_2V_2$
   Combined $P_1V_1/T_1 = P_2V_2/T_2$
   Ideal: $PV = nRT$
10. Ideal: P in kPa, V in L, n in mol, T in K, R in kPa•L / mol•K (otherwise units don't cancel). All others: any units for P or V, T must be K.
11. **5<u>0</u>0 kPa**: Using $P_1V_1 = P_2V_2$, P_1= 100 kPa, V_1= 10 mL, V_2= 2.0 mL, P_2= ?
12. **2.46 L**: Using $V_1/T_1 = V_2/T_2$, V_1 = 2.00 L, T_1 = 295 K, V_2 = ?, T_2 = 363 K
13. **391 kPa**: $P_1V_1/T_1 = P_2V_2/T_2$ or $P_1/T_1 = P_2/T_2$ P_1 = 200 kPa, T_1 = 293 K, P_2 = ?, T_2 = 573 K

14. **34.4 mL**: Using $P_1V_1/T_1 = P_2V_2/T_2$, P_1 = 3.40 atm, V_2 = 10.0 mL, T_1 = 277 K P_2 = 1.0<u>1</u>65 atm, V_2 = ?, T_2 = 285 K
15. Volume will expand if T↑, or P_{atm}↓ .
16. ↑T will cause P↑, if volume is constant.
17. Using $PV = nRT$ and converting T into K ...
    n=(90 kPa)(2 L) / (8.31 kPa•L/mol•K)(293 K)
    a) = 0.0739 mol. b) = 4.45 x 10^{22} molecules
    c) g/mol = 10.0 g / 0.0739 mol = 135 g/mol
18. Using $PV = nRT$
    T = (150 kPa)(0.47 L) / (0.70 mol)(8.31 ...)
    T = 12 K or -261 °C
19. N_2 (78.08%), O_2 (20.95%), argon (0.93%), CO_2 (0.04%). Percentages are for dry air.

20. A liquid boils when its vapour pressure is equal to the atmospheric (i.e. surrounding) pressure. 30°C water will boil at 4.24 kPa (see page 464).
21. The total pressure of a mixture of gases equals the sum of their individual pressures. (i.e. $P_{total} = P_1 + P_2 + P_3 + ...$).
22. 1 mol O_2 exerts the same pressure as 1 mol N_2 at the same temperature and volume. There are 10 moles of gas all together. Each mole of gas exerts 20 kPa of pressure (200 kPa divided among 10 moles), thus 2 mol O_2 exert 40 kPa and 8 mol N_2 exert 160 kPa.

23. 1) the level of the liquid inside and outside the container must be equal so that the pressure in the jar is equal to atmospheric, 2) the pressure due to water vapor must be subtracted from the pressure of the gas in the collecting jar (see pg. 464), 3) the combined gas law is used to convert to STP.
24. V_1 = 500 mL, T_1 = 295 K (22+273), P_1 = ...
    P_1=101.0 kPa - 2.64 kPa (pg 464)=98.<u>3</u>6 kPa
    V_2 = ?, T_2 = 273 K, P_1 = 101.3 kPa
    Using $P_1V_1/T_1 = P_2V_2/T_2$, V_2 = **449 mL**
25. 1 mol of any gas occupies 22.4 L at STP. For O_2, 1 mol= 32 g. g/L= 32/22.4 = 1.43 g/L
26. 0.73 mol x 22.4 L/mol= 16.4 L (or use PV=nRT)

27. Avogadro's theory: equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. His ideas are based on the law of combining gas volumes (volumes of reacting gases are always in simple, whole number ratios).
28. Gases at the same temperature and pressure have the same # of molecules. The reason why gases have different densities is because molecules of different gases have different masses; gases with heavy molecules (high molar masses) have high densities.

29. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
    # mol CO_2=
    $$50 \text{ g } C_3H_8 \times \frac{1 \text{ mol } C_3H_8}{44.11 \text{ g } C_3H_8} \times \frac{3 \text{ mol } CO_2}{1 \text{ mol } C_3H_8} = \frac{3.4 \text{ mol}}{CO_2}$$
    V = 95 L: Using $PV = nRT$,
    V=(3.4 mol)(8.31 kPa•L/mol•K)(303 K) /(90 kPa)
30. a)
    # L O_2=   = 0.557 L O_2
    $$1.46 \text{ g } ZnS \times \frac{1 \text{ mol } ZnS}{97.44 \text{ g } ZnS} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } ZnS} \times \frac{24.8 \text{ L } O_2}{1 \text{ mol } O_2}$$
    # L SO_2= 0.557 L O_2 $\times \frac{2 \text{ L } SO_2}{3 \text{ L } O_2}$ = 0.372 L SO_2