Chemistry 20 Final Review

Gases Checklist

Have you mastered the concepts, applications, and skills associated with the following items? Check them off when you are confident in your understanding.

Knowledge

- express atmospheric pressure in a variety of ways, including units of mm Hg, atm, and kPa
- convert between the Celsius and absolute (kelvin) temperature scales
- describe and compare the behaviour of real and ideal gases in terms of kinetic molecular theory
- explain the law of combining volumes
- illustrate how Boyle's, Charles', and combined gas laws are related to the ideal gas law
- perform calculations based on the ideal gas law under STP, SATP, and other conditions

Key Terms

pressure	atmospheric pressure
STP	SATP
Boyle's law	absolute zero
absolute temperature scale	Charles' law
combined gas law	law of combining volumes
Avogadro's theory	molar volume
ideal gas	ideal gas law
universal gas constant	

Gases

1. Convert the following:
   a. 235 torr to kPa (31.3 kPa) $235\ torr \times \frac{101.3\ kPa}{760\ torr} = 31.3\ kPa$
   b. 180 kPa to mm Hg (1.35 x 10^3 mmHg) $180\ kPa \times \frac{760\ mmHg}{101.3\ kPa} = 1.35 \times 10^3\ mmHg$
   c. 2.34 atm to kPa (237 kPa) $2.34\ atm \times \frac{101.3\ kPa}{1\ atm} = 237\ kPa$
   d. 24ºC to Kelvin (297 K) $24°C + 273 = 297\ K$
   e. 987 K to ºC (714 °C) $987\ K - 273 = 714°C$
2. Give the conditions for STP. 0°C, 101.3 kPa
3. Give the conditions for SATP. 25°C, 100 kPa.

4. An unknown gas has a pressure of 469 mm Hg and occupies 29.0 ml. What would be the new volume if the pressure was changed to 0.998 atm? (17.9 mL)

$0.998\,atm \times \frac{760\,mmHg}{1\,atm} = 758.48\,mmHg$

$P_1V_1 = P_2V_2$

$469\,mmHg \cdot 29.0\,mL = 758.48\,mmHg \cdot V_2$

$V_2 = 17.9\,mL$

5. What would be the initial pressure (in mm Hg) of a hydrogen gas if it was changed to 660 torr and had a volume of 89.0 liters that was initially 80.9 liters? (726 torr)

$P_1V_1 = P_2V_2$

$660\,torr \cdot 89.0\,L = P_2 \cdot 80.9\,L$

$P_2 = 726\,torr.$

6. What does absolute zero mean?

All particles stop moving. There will be no spaces between particles.

7. What would be the new volume of oxygen gas when pressure remains constant if the temperature changed from 39 ºC to 55 ºC and its initial volume was 685 ml? (720 mL)

$T_1 = 312\,K$

$T_2 = 328\,K$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{685\,mL}{312\,K} = \frac{V_2}{328\,K}$

$V_2 = 720\,mL.$

8. A sample of nitrogen gas exerts 52.6 kPa at 66 ºC. What pressure would the gas exert at 99ºC if the container's volume remains the same? (57.7 kPa)

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{52.6\,kPa}{339\,K.} = \frac{P_2}{372\,K}$

$P_2 = 57.7\,kPa$

$T_1 = 339\,K$

$T_2 = 372\,K.$

9. What would be the final temperature of a gas (in ºC) if the pressure went from 780 mm Hg to 150.8 kPa and had an initial temperature of 26 ºC? (161 °C)

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $\frac{103.97 \text{ kPa}}{299 \text{ K}} = \frac{150.8 \text{ kPa}}{T_2}$ $T_2 = 434 \text{ K} = 161 °C$

$P_1 = 780 \text{ mmHg} \times \frac{101.3 \text{ kPa}}{760 \text{ mmHg}}$

$P_1 = 103.97 \text{ kPa}$

10. Helium gas in a hot air balloon experiences a temperature change from 21ºC to 55 ºC and an atmospheric pressure change from 100 kPa to 88.5 kPa. What would be the new volume of the hot air balloon if its initial volume was 125 kiloliters? (1.58×10^5L)

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{100 \text{ kPa} \times 125 \text{ kL}}{294 \text{ K}} = \frac{88.5 \text{ kPa} \times V_2}{328 \text{ K}}$ $V_2 = 158 \text{ kL}$

11. A 2.7 liter sample of nitrogen gas is collected at a temperature of 45 ºC and a pressure of 0.92 atm. What pressure would have to be applied to the gas to reduce its volume to 2.0 liters at a temperature of 25.0 ºC? (1.2 atm)

$T_1 = 318 \text{ K}$

$T_2 = 298.0 \text{ K}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{0.92 \text{ atm} \cdot 2.7 \text{ L}}{318 \text{ K}} = \frac{P_2 \cdot 2.0 \text{ L}}{298.0 \text{ K}}$

$P_2 = 1.2 \text{ atm}$

12. A sample of argon gas occupies a volume of 2.0 L at -35ºC at 1.2 atm. What would its Celsius temperature be at 2.0 atm if its volume decreases to 1.5 L? (25 °C)

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{1.2 \text{ atm} \cdot 2.0 \text{ L}}{238 \text{ K}} = \frac{2.0 \text{ atm} \cdot 1.5 \text{ L}}{T_2}$

$T_2 = 298 \text{ K} = 25 °C$

$T_1 = 238 \text{ K}$

$V_1 = 2.0 \text{ L}$

$P_1 = 1.2 \text{ atm}$

13. What pressure would 2.00 Kmol of fluorine gas exert under 45ºC with a volume of 985 ml? (5.4×10^6kPa)

$P = \frac{nRT}{V}$ $P = \frac{2000 \text{ mol} \cdot 8.314 \frac{\text{L} \cdot \text{kPa}}{\text{K mol}} \cdot 318 \text{ K}}{0.985 \text{ L}}$

$P = 5.4 \times 10^6 \text{ kPa}$

14. What mass of sulfur gas would be found in a 2.45 liter container at SATP? (25.4 g)

$T = 298\ K$
$P = 100\ kPa$
$V = 2.45\ L$

$n = \frac{PV}{RT}$

$= \frac{100\ kPa \cdot 2.45\ L}{8.314\ \frac{L \cdot kPa}{K\ mol} \cdot 298\ K}$

$n = 0.0989\ mol$

$0.0989\ mol\ S_{8(g)} \times \frac{256.56\ g\ S_8}{1\ mol\ S_8}$

$= 25.4\ g$

15. What would be the volume of 3.52 mg of chlorine gas at 21ºC under 99.2 kPa of pressure? (1.22 mL)

$T = 294\ K$

$n = 3.52 \times 10^{-3}\ g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.90\ g\ Cl_2}$

$= 4.96 \times 10^{-7}\ mol$

$V = \frac{nRT}{P}$

$= \frac{4.96 \times 10^{-7}\ mol \cdot 8.314\ \frac{L \cdot kPa}{K\ mol} \cdot 294\ K}{99.2\ kPa}$

$V = 0.00122\ L\ Cl_2$

16. What volume of oxygen gas would occupy at STP that has a mass of 9.45 grams? (6.62 L)

$n = 9.45\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g\ O_2}$

$= 0.295\ mol\ O_2$

$V = \frac{nRT}{P}$

$= \frac{0.295\ mol \cdot 8.314\ \frac{L \cdot kPa}{K\ mol} \cdot 273\ K}{101.3\ kPa}$

$V = 6.62\ L.$

17. Oxygen gas and magnesium react to form 2.43 g of magnesium oxide. What volume of oxygen gas at 94.9 kPa and 25.0ºC would be consumed to produce this amount of $MgO_{(s)}$? (786 mL)

$O_{2(g)} + 2Mg_{(s)} \rightarrow 2MgO_{(s)}$

$2.43\ g\ MgO \times \frac{1\ mol\ MgO}{40.31\ g\ MgO} \times \frac{1\ mol\ O_2}{2\ mol\ MgO}$

$n_{O_2} = 0.0301\ mol$

$V = \frac{nRT}{P}$

$= \frac{0.0301\ mol \cdot 8.314\ \frac{L \cdot kPa}{K \cdot mol} \cdot 298\ K}{94.9\ kPa}$

$V = 0.786\ L$

18. Nitrogen triodide decomposes into explosive nitrogen gas and iodine. Calculate the volume of each gas produced at STP when 395 mg of NI_3 (g) decomposes. Calculate the mass of each gas produced. (N_2 = 11.2 mL, 0.0140 g – I_2 = 336 mL, 0.381 g)

$$2NI_{3(g)} \rightarrow N_{2(g)} + 3I_{2(g)}$$

$$0.395\,g\,NI_3 \times \frac{1\,mol\,NI_3}{394.71\,g\,NI_3} \times \frac{3\,mol\,I_2}{2\,mol\,NI_3} \times \frac{22.4\,L\,I_2}{1\,mol\,I_2} = 0.0336\,L\,I_2$$

$$\times \frac{253.8\,g\,I_2}{1\,mol\,I_2} = 0.381\,g\,I_2$$

$$0.395\,g\,NI_3 \times \frac{1\,mol\,NI_3}{394.71\,g\,NI_3} \times \frac{1\,mol\,N_2}{2\,mol\,NI_3} \times \frac{22.4\,L\,N_2}{1\,mol\,N_2} = 0.0112\,L$$

$$\frac{28.02\,g\,N_2}{1\,mol\,N_2} = 0.0140\,g\,N_2$$

19. A 2.00 liter of sample of ethane, C_2H_6, is burned at 1.00 atm and 25.0 ºC with 1.50 liters of oxygen. What is the mass of water vapor will be produced from the burning of ethane? What would be the volume of the water vapor under the same conditions? (Hint: determine the limiting reagent!) (m = 1.96 g; v = 1.29 L.

$$2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$$

$$2.00\,L\,C_2H_6 \times \frac{6\,L\,H_2O}{2\,L\,C_2H_6} = 6.00\,L\,H_2O$$

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$$1.50\,L\,O_2 \times \frac{6\,L\,H_2O}{7\,L\,O_2} = 1.29\,L\,H_2O$$

$$0.0613\,mol\,O_2 \times \frac{32.00\,g\,O_2}{1\,mol\,O_2}$$

$$m_{O_2} = 1.96\,g$$

$$n = \frac{PV}{RT}$$

$$n = \frac{101.3\,kPa \cdot 1.50\,L\,O_2}{8.314\,\frac{L \cdot kPa}{K\,mol} \cdot 298.0\,K}$$

$$n = 0.0613\,mol\,O_2$$