SCH3U

Grade 11 Gases and Atmospheric Chemistry

Unit Overview

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Ontario Curriculum 2008: Grade 11 Gas Laws and Atmospheric Chemistry

OVERVIEW

This course enables students to deepen their understanding of chemistry through the study of the properties of chemicals and chemical bonds; chemical reactions and quantitative relationships in those reactions; solutions and solubility; and atmospheric chemistry and the behaviour of gases. Students will further develop their analytical skills and investigate the qualitative and quantitative properties of matter, as well as the impact of some common chemical reactions on society and the environment.

Fundamental Concepts	**Big Ideas**
Matter Energy Structure and Function Sustainability and Stewardship	• Properties of gases can be described qualitatively and quantitatively, and can be predicted. • Air quality can be affected by human activities and technology. • People have a responsibility to protect the integrity of Earth's atmosphere.

Overall Expectations

By the end of Grade 11, students will:

1. analyze the cumulative effects of human activities and technologies on air quality, and describe some Canadian initiatives to reduce air pollution, including ways to reduce their own carbon footprint;
2. investigate gas laws that explain the behavior of gases, and solve related problems;
3. demonstrate an understanding of the laws that explain the behavior of gases.

Specific Expectations

By the end of this course, students will:
F1.1 analyse the effects on air quality of some technologies and human activities (e.g., smelting; driving gas-powered vehicles), including their own activities, and propose actions to reduce their personal carbon footprint [AI, C] Sample issue: Gas-powered lawnmowers cut grass quickly and efficiently, but they emit greenhouse gases. However, there are several alternatives, including electric or push mowers or replacing lawn with a naturalized garden.
Sample questions: In what ways does our consumption of products imported from distant countries affect our carbon footprint? How might "eat local–buy local" initiatives help to reduce our carbon footprint? How effectively does the use of digital communications for business reduce our carbon footprint?
F1.2 assess air quality conditions for a given Canadian location, using Environment Canada's Air Quality Health Index, and report on some Canadian initiatives to improve air quality and reduce greenhouse gases (e.g., Ontario's Drive clean program to control vehicle emissions)
F2.1 use appropriate terminology related to gases and atmospheric chemistry, including, but not limited to: standard temperature, standard pressure, molar volume, and ideal gas [C]
F2.2 determine, through inquiry, the quantitative and graphical relationships between the pressure, volume, and

temperature of a gas [PR, AI]
F2.3 solve quantitative problems by performing calculations based on Boyle's law, Charles's law, Gay-Lussac's law, the combined gas law, Dalton's law of partial pressures, and the ideal gas law [AI]
F2.4 use stoichiometry to solve problems related to chemical reactions involving gases (e.g., problems involving moles, number of atoms, number of molecules, mass, and volume) [AI]
F2.5 determine, through inquiry, the molar volume or molar mass of a gas produced by a chemical reaction (e.g., the molar volume of hydrogen gas from the reaction of magnesium with hydrochloric acid) [PR, AI] Air Quality Health Index, and report on some Canadian initiatives to improve air quality and reduce greenhouse gases (e.g., Ontario's Drive Clean program to control vehicle emissions) [AI, C]
F3.1 identify the major and minor chemical components of Earth's atmosphere
F3.2 describe the different states of matter, and explain their differences in terms of the forces between atoms, molecules, and ions
F3.3 use the kinetic molecular theory to explain the properties and behaviour of gases in terms of types and degrees of molecular motion
F3.4 describe, for an ideal gas, the quantitative relationships that exist between the variables of pressure, volume, temperature, and amount of substance
F3.5 explain Dalton's law of partial pressures, Boyle's law, Charles's law, Gay-Lussac's law, the combined gas law, and the ideal gas law
F3.6 explain Avogadro's hypothesis and how his contribution to the gas laws has increased our understanding of the chemical reactions of gases

Achievement Chart Key
K/U = Knowledge and Understanding, T/I = Thinking and Investigation, C = Communication, A = Application

Unit Overview – Outline of Lessons

Day	Lesson	Lesson Strategy and Assessment	Expectation Code	Evaluation
1	Greenhouse Effect	Present Key Questions for this lesson • What do you think about when you hear the term "Climate Change?" • What is the evidence that Earth's climate is changing? • Do you think people have caused Earth's climate to change? • How do you think climate change will impact the world? North America? Yourself? Hook: You Tube video, e.g. http://www.youtube.com/watch?v=GAi8Lxf8JXA Teacher will present a slideshow presentation on The Greenhouse Effect that outlines some ways that technologies and human activities impact air quality	F1.1 F1.2 F3.1	During the activity, the teacher walks around, looking at individual concept maps [K/U] The teacher could also collect the initial concept maps, to use as a diagnostic, to help plan future lessons. [K/U, C]

		Activities - Students draw a mind map/concept map on climate change. If they know how to use the Ministry-licensed software, Smart IDEAS, they can work in the computer lab. The concept map should show initial knowledge about climate change.		
2	Ozone and Components of the atmosphere	Teacher will present a slideshow on the Effect of Ozone. Students will know that the atmosphere consists of different gases. Included in the slideshow will be discussion of Environment Canada's Air Quality Health Index, and some Canadian initiatives to improve air quality. **Activities** – Teacher will provide organizer and students will research air quality for Canadian cities and report on initiative to reduce air pollution.	F1.1 F1.2 F2.1 F3.1	Teacher will observe and question students as they conduct research. [K/U, C]
3	Introduction to gases	Diagnostic test covering the entire unit. Class discusses answers. Definition: What is a gas? Watch You Tube video or Discovery video on gases Power Point discussion on the Kinetic Molecular Theory	F2.1 F3.3	Collect test for diagnostic purposes [K/U, T/I]
4	Kinetic Molecular Theory and Unit Conversions for the Gas Laws	Class discussion and PowerPoint on Kinetic Molecular Theory continued. How to state standard atmospheric pressure in the following units: atm, mm Hg, torr, cm Hg, in. Hg, psi, and kPa. How to convert a given gas pressure into a different unit of measurement. **Activities** - Students will work to complete a table showing gas conversion units	F2.1 F3.3	Students will complete and submit the worksheet. [K/U, T/I]
5	BOYLE'S LAW CHARLES' LAW LAB 1	Teacher will provide brief lecture and discussion on Boyle's Law and Charles' Law. **Activities**: Students will work in small groups perform the following experiments to demonstrate Boyle's Law and Charles' Law	F2.1 F2.2 F2.3	Students will complete exit ticket before the end of class. [K/U, T/I] Students will hand in their observations before the end

	(This might require two days)	**Workstations**: ○ Balloon in a Bell Jar ○ Marshmallow in a Bell Jar ○ Shaving Cream in a Beaker in a Bell Jar ○ Cartesian Diver ○ Balloon on a Flask ○ Balloon Outside vs. Balloon Inside Students record obsevations at each work station Students will complete related Gizmos Activity online and complete the Student Activity Sheet. http://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=422 Exit Ticket. Complete one question	F3.1 F3.3 F3.4	of class; teacher to use this as diagnostic assessment of observation skills [T/I] Students will submit worksheet completed for homework. [T/I]
6	GAY-LUSSAC'S LAW COMBINED GAS LAW	Teacher will provide PowerPoint presentation and lead discussion on Gay-Lussac's Law and the Combined Gas Law **Activities** - Demonstrations Students will work in small groups to perform the following experiments to demonstrate Gay-Lussac's Law . Volume is constant while pressure and temperature change. ○ Egg on a Flask ○ Drinking Novelty Bird ○ Novelty Hand Boiler Students will work in their groups to complete a related worksheet . Exit Ticket: Students will write and submit explanations for 3 everyday occurrences of these laws	F2.3	Collect Exit Tickets [K/U] Teacher listens to groups discussion [K/U, C] Observes students conducting experiments. [T/I]

7	Ideal Gas Law and the Combined Gas Law	Teacher will demonstrate problem solving methods using the Ideal and Combined Gas Law. **Activities:** Students will work in small groups to solve quantitative problems by performing calculations based on Boyle's law, Charles's law, Gay-Lussac's law, the combined gas law, and the ideal gas law Teacher will facilitate discussion around these problems. Students will complete worksheet.	F2.1 F2.2 F2.3 F3.4	Teacher listens to student discussions. [K/U, C] Addresses any misconceptions [K/U]
8	Avogadro's Law	Teacher will provide PowerPoint and lead discussion on Avogadro's Law. Students will work on related problems. Culminating Task Assigned. Culminating task will have an STSE component, which will incorporate RAFT (role-audience-format-topic). <u>Overview of Culminating Task</u>: Students work in groups of three or four. Students research a particular gas from a list, such as methane, chloroform, terpenes, carbon dioxide, CFCs, nitrogen oxides etc. and prepare a presentation discussing the effects this gas has on our atmosphere, its contributions to air quality and climate change. Students must consider the sources of the gas, how the gas reacts in the atmosphere, the gas's volatility, bioaccumulation etc. Students must also find and summarize a relatively recent research article discusses their particular their gas relative to the atmosphere.	F3.6	Teacher takes up any questions students may have [K/U, T/I]
9	Quiz Review and Project Work Period	Students work on Gas Laws review sheet and work in groups on Culminating Task Brief question and answer period for review		Question and answer period allows teacher to determine students' level of understanding prior to tomorrow's quiz, and to review [K/U, T/I]
10	Quiz	Students will write a quiz covering the content they have learned. Quiz to include application questions as well.		Collect Quiz [K/U, T/I, C, A]
11	THE VAPOR PRESSURE CONCEPT	Teacher will lead discussion on the concept of vapor pressure and introduce the relationship between vapor pressure and temperature. Students will complete activity based on the	F2.1	Teacher will collect completed activity at end of class [T/I, A]

		oxygen composition in the atmosphere		
12	Dalton's Law of Partial Pressures	Teacher leads discussion and provides examples of how to use Dalton's Law of Partial Pressures to predict the pressure of a gas mixture Students work on practice problem. Exit Ticket: Complete a reflection on how our lives are affected by gases	F3.5 F2.3	Collect exit ticket. [K/U]
13	Gas Stoichiometry	Teacher provides practice problem which the class completes collectively Students will work in small groups to complete worksheet.	F2.4	Teacher collects worksheet at end of class [K/U, T/I]
14	LAB 2: Production of Hydrogen Gas	**Objectives:** Experimentally determine the volume of gas that produced. **LAB 2:** Students will perform an experiment to observe the Reaction of Magnesium with Hydrochloric Acid In this experiment students will determine the volume of the hydrogen gas which is produced when a sample of magnesium reacts with hydrochloric acid. The volume of the hydrogen gas produced will be measured at room temperature and pressure. Students will compare their experimental measurements with those calculated using the ideal gas law. Students will obtain data and answer question from a worksheet.	F2.5	Collect lab report next day. [K/U, T/I, C, A]
15	Work Period	Work Period to complete Lab 1 and Culminating Task		Teacher fields any questions that students may have
16	Presentations	Students Present Culminating Task		Teacher will observe and mark student presentations according to preassigned rubric [K/U, T/I, C, A]
17/18	Presentations	Student Present Culminating Task		Teacher will observe and mark student presentations according to preassigned rubric [K/U, T/I, C, A]

19	Test Review	Teacher will engage the class in review activities and provide review questions.		
20	**Unit Test**		F1.1 -F3.6	Teacher marks unit test [K/U, T/I, C, A]

CULMINATING TASK: Chemicals in Our Atmosphere

For this culminating task, you will be getting into groups of three or four. Together, you will be choosing one chemical that is commonly found in our atmosphere, and creating a presentation on the effects of this chemical on air quality, human health and our climate. This task will have three components: a visual component, a written component and finally, a primary article summary. You will be given a period to complete the work, but whatever is not finished may be taken for homework to submit the next day. **Use the in-class time wisely, since the assignment is long and since you have the opportunity to ask me questions.** Only ONE completed culminating task is to be submitted per group. You will be presenting your completed culminating task to the class in a 10min oral presentation.

PART 1: Written Component (K, T/I, A)

Choose one of the following chemicals from the list below:

Terpenes
CFCs
Carbon dioxide
Methane
Chloroform
Nitrogen oxides

You will prepare a report discussing the effects of your chosen chemical. You must provide some background information on your chemical. What is the chemical formula and structure? What are the sources of the chemical? What are the chemical properties of your compound (be sure to discuss its state at STP, volatility, bioaccumulation)? In which layers of our atmosphere is the chemical commonly found? Be sure to draw upon the various gas laws to explain your chemicals presence in the atmosphere. You must also discuss the effect your chemical has on our atmosphere, its contributions to air quality and climate change. What reactions does the chemical undergo? What are its effects on human health and wellbeing?

Your report should be roughly 1500-2000 words. Use subheadings and proper APA format. Be sure to include properly cited references.

HINT: It would be very beneficial for you to use the required primary article from PART 3 as one of your sources :).

PART 2: Visual Component (C)

For this section, you must present a summarized version of the information in your report in a visual way. Get really creative for this component! You can prepare a brochure on your chemical, a short video documentary, an oral presentation to the Ministry of Environment, a public service commercial, etc. The options are plentiful! Be sure to confirm your ideas with me before you begin the visual component of this culminating task. Your visual will play a vital role in your oral presentation.

PART 3: Primary article (C)

Find and read a relatively recent news article that discusses your chosen chemical together as a group. Highlight key pieces of information as you go. Try to understand as much as you can, and if you have any questions, make sure to ask me, so you get a full understanding of what has been written. Once you have done that, write a BRIEF summary of the article (4-6 sentences), discussing the main idea. Attach the article and summary to your report.

Here are a list of some helpful resources you may use in this assignment:

Environmental Protection Agency
http://www.epa.gov/air/urbanair/
New York Times
http://topics.nytimes.com/top/news/science/topics/air_pollution/index.html
Natural News
http://www.naturalnews.com/air_pollution.html
Science Daily
http://www.sciencedaily.com/articles/earth_climate/air_quality/
Guardian UK
http://www.guardian.co.uk/environment/2012/mar/15/air-pollution-biggest-killer-water
Times of India
http://articles.timesofindia.indiatimes.com/keyword/air-pollution
National Geographic
http://environment.nationalgeographic.com/environment/global-warming/pollution-overview/
Natural Resources Defense Council
http://www.nrdc.org/air/
Washington Post
http://www.washingtonpost.com/business/apnewsbreak-epa-to-review-rule-on-toxic-air-pollution-standards-for-future-plants-targeted/2012/07/20/gJQA8BhUyW_story.html

CULMINATING TASK: "Chemicals in our Atmosphere" RUBRIC

CATEGORIES	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Knowledge and Understanding	Demonstrates knowledge and understanding of terms and concepts regarding chemicals, gas laws and our atmosphere with LIMITED effectiveness	Demonstrates knowledge and understanding of terms, and concepts regarding chemicals, gas laws and our atmosphere with SOME effectiveness	Demonstrates knowledge and understanding of terms, and concepts regarding chemicals, gas laws and our atmosphere with CONSIDERABLE effectiveness	Demonstrates knowledge and understanding of terms, and concepts regarding chemicals, gas laws and our atmosphere with a HIGH DEGREE of effectiveness
Thinking	Uses critical thinking to draw conclusions on effects of chemicals on atmosphere with LIMITED effectiveness	Uses critical thinking to draw conclusions effects of chemicals on atmosphere with SOME effectiveness	Uses critical thinking to draw conclusions on effects of chemicals on atmosphere with CONSIDERABLE effectiveness	Uses critical thinking to draw conclusions on effects of chemicals on atmosphere with a HIGH DEGREE of effectiveness
Communication	Summarizes the primary article and provide a clear and creative visual with LIMITED effectiveness	Summarizes the primary article and provide a clear and creative visual with SOME effectiveness	Summarizes the primary article and provide a clear and creative visual with CONSIDERABLE effectiveness	Summarizes the primary article and provide a clear and creative visual with a HIGH DEGREE of effectiveness
Application	Relates the topics discussed in class, (air quality, Green House effect etc.) unit to the chemical with LIMITED effectiveness	Relates the topics discussed in class, (air quality, Green House effect etc.) unit to the chemical with SOME effectiveness	Relates the topics discussed in class, (air quality, Green House effect etc.) unit to the chemical with CONSIDERABLE effectiveness	Relates the topics discussed in class, (air quality, Green House effect etc.) unit to the chemical with a HIGH DEGREE of effectiveness

Name: _____

SCH3U Unit F: Gases and Atmospheric Chemistry Test (Total: **/58 marks**)

Knowledge & Understanding	Thinking & Investigation	Communication	Application
/24	/17	/11	/6

Part 1: Knowledge and Understanding **(/24 marks)**

Use each of the following terms to **fill in the blanks** (each term may be used more than once) **(9 marks)**: **Pressure**, **Temperature**, **Volume**

1) Boyle's law relates (a) _____ and (b) _____ if (c) _____ and amount of gas are held constant.

2) Charles's law relates (d) _____ and (e) _____ if (f) _____ and amount of gas are held constant.

3) Gay-Lussac's law relates (g) _____ and (h) _____ if (i) _____ and amount of gas are held constant

Theory

4) State the Ideal Gas Law. What does each variable stand for and what are the SI units of the variables? What is an Ideal Gas? Describe the properties of an ideal gas with reference to at least 3 postulates of the kinetic molecular theory. **(10 marks)**

Multiple choice (**5 marks; 1 mark for each correct answer)**

5) What volume does 3.20 grams of methane gas, $CH_4(g)$ occupy at 0^oC and 101.325 kPa? Choose the closest answer

A) 1.12 L
B) 2.24 L
C) 3.40 L
D) 4.48 L
E) 22.4 L

Name: _____

6) A 10.0 L container has a sample of $O_2(g)$ at 25oC and 51 kPa. A second 10.0 L container has a sample of $CH_4(g)$, also at 25ºC and 51 kPa. Assuming ideal gas behavior, which of the following statements concerning these two samples is correct?

(1) They contain the same number of molecules.
(2) They have the same density.
(3) The molecules in the two samples have the same average kinetic energy.

A) (1) and (2)
B) (2) and (3)
C) (1) and (3)
D) (1) only
E) (3) only

7) A 0.322 g sample of an unknown gas occupies a volume of 0.500 L at 100ºC and 50.0 kPa. What is the molar mass of the gas?

A) 160 g/mol
B) 40 g/mol
C) 16g/mol
D) 29 g/mol
E) 25 g/mol

8) What is the density of carbon dioxide gas at 0.00 ºC and 101.3 kPa

A) 1.96 g/L
B) 0.0446 g/L
C) 22.4 g/L
D) 44.6 g/L
E) 0.509 g/L

9) A 1.0 L sample of $N_2(g)$ has a pressure of exactly 100 kPa. A 2.0 L sample of $O_2(g)$ has a pressure of 50 kPa at the same temperature. The samples are mixed and forced into a 1.0 L container. Assuming that no raection occurs and that the temperature remains constant, what is the final pressure of the mixture?

A) 25 kPa
B) 50 kPa
C) 100 kPa
D) 150 kPa
E) 200 kPa

Name: _____

Part 2: Thinking and Investigation **(/17 marks)**

Short answer: Show all your calculations.

10) Assuming that gases behave ideally, if the temperature is 280°C with a pressure of 100.5 kPa, and 15.0 g of ammonium nitrate (NH_4NO_3) decomposes what is the total volume of gas produced? (Hint: ammonium nitrate decomposes into nitrogen, hydrogen, and oxygen gas) **(4 marks)**

11) A 1L steel tank is fitted with a safety valve that opens if the internal pressure exceeds 1.00×10^3 torr. It is filled with helium at 23°C and 0.991 atm and placed in boiling water at exactly 100°C. Will the safety valve open? (Hint: 760 torr = 1 atm) **(5 marks)**

Name: _____

12) A tank contains a mixture of gases as follows: 92 g of nitrogen dioxide, 48 g of methane, 64 g of sulfur dioxide, and 64 g of oxygen. Given that the partial pressure of oxygen is 60.0 kPa, find the total pressure of the mixture of gases and the partial pressures of each gas in the tank. **(8 marks)**

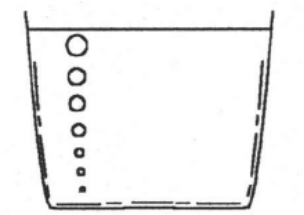
Part 3: Communication **(/11 marks)**

13) The following data is for 132 g of $CO_{2(g)}$. The experimental temperature was kept at a constant 55°C. Complete the table, and **graph** your results. Are the results consistent with the Ideal Gas Law? Why or why not? **(7 marks)**

Trial:	1	2	3
Pressure (kPa)	101.3		
Volume (L)		59.85	70.50

Name: _____

14a) The diagram shows some bubbles rising in a glass of a fizzy drink. Explain why the bubbles get larger as they rise to the surface. (Hint: consider the ideal gas equation) **(3 marks)**



b) What assumption are you making? **(1 mark)**

Part 4: Application **(/6 marks)**

15) The alkali metals [Group 1A(1)] react with the halogens [Group 7A(17)] to form ionic metal halides. What mass of potassium chloride forms when 5.25 L of chlorine gas at 0.950 atm and 293 K reacts with 17.0 g of potassium? (Hint: R = 0.0821 L atm/ mol K) **(6 marks)**

Name: _____TEACHER COPY_____

SCH3U Unit F: Gases and Atmospheric Chemistry Test (Total: **/58 marks**)

Knowledge & Understanding /24	Thinking & Investigation /17	Communication /11	Application /6

Part 1: Knowledge and Understanding **(/24 marks)**

Use each of the following terms to **fill in the blanks** (each term may be used more than once)
(9 marks): Pressure, Temperature, Volume <1 mark for each correct answer>

1) Boyle's law relates (a) **pressure** and (b) **volume** if (c) **temperature** and amount of gas are held constant.

2) Charles's law relates (d) **temperature** and (e) **volume** if (f) **pressure** and amount of gas are held constant.

3) Gay-Lussac's law relates (g) **pressure** and (h) **temperature** if (i) **volume** and amount of gas are held constant

Theory

4) State the Ideal Gas Law. What does each variable stand for and what are the SI units of the variables? What is an Ideal Gas? Describe the properties of an ideal gas with reference to at least 3 postulates of the kinetic molecular theory. **(10 marks)**

ANSWER

Ideal Gas Law:

PV = nRT	P = pressure in kPa V = volume in L n = moles of gas R = gas constant = 8.314 J/mol*K T = temperature in K
<1 mark>	<5 marks total; half mark for each SI unit and variable>

An ideal gas is one that follows the ideal gas law. Ideal gases do no actually exist in nature. They differ from non-ideal gases because we make the following assumptions about them (based on Kinetic Molecular Theory). (1) Ideal gases consist of small particles that are in continuous random motion. (2) The volume of particles present is negligible compared to the total volume occupied by the ideal gas. (3) Intermolecular (attraction and repulsion) forces are neglibile. For non-ideal gases, at high pressures volume becomes significant; and at low temperatures intermolecular forces are significant.
<1 mark for explaining what an ideal gas is, 3 marks for postulates>
Other acceptable answers: (4) Pressure is the result of gas particles colliding with the walls of the container, (5) The average kinetic energy of the molecules remains constant while temperature of gas remains constant; collisions are perfectly elastic.

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Multiple choice (**5 marks; 1 mark for each correct answer**) <1 mark for each correct answer>

5) What volume does 3.20 grams of methane gas, $CH_4(g)$ occupy at 0°C and 101.325 kPa? Choose the closest answer

A) 1.12 L
B) 2.24 L
C) 3.40 L
D) 4.48 L
E) 22.4 L

ANSWER: PV = nRT; solve for n, convert to grams using molar mass of CH_4

6) A 10.0 L container has a sample of $O_2(g)$ at 25oC and 51 kPa. A second 10.0 L container has a sample of $CH_4(g)$, also at 25°C and 51 kPa. Assuming ideal gas behavior, which of the following statements concerning these two samples is correct?

(1) They contain the same number of molecules.
(2) They have the same density.
(3) The molecules in the two samples have the same average kinetic energy.

A) (1) and (2)
B) (2) and (3)
C) (1) and (3)
D) (1) only
E) (3) only

7) A 0.322 g sample of an unknown gas occupies a volume of 0.500 L at 100°C and 50.0 kPa. What is the molar mass of the gas?

A) 160 g/mol
B) 40 g/mol
C) 16g/mol
D) 29 g/mol
E) 25 g/mol

ANSWER: use PV = nRT to solve for n; n = m/M (mass over molar mass), solve for M

8) What is the density of carbon dioxide gas at 0.00 °C and 101.3 kPa

A) 1.96 g/L
B) 0.0446 g/L
C) 22.4 g/L
D) 44.6 g/L
E) 0.509 g/L

ANSWER: n = m/M (where m = mass, and M = molar mass), so:

Name: TEACHER COPY

$$PV = \frac{m}{M}RT \quad d = \frac{m}{V} \quad d = \frac{M \times P}{RT}$$

9) A 1.0 L sample of $N_2(g)$ has a pressure of exactly 100 kPa. A 2.0 L sample of $O_2(g)$ has a pressure of 50 kPa at the same temperature. The samples are mixed and forced into a 1.0 L container. Assuming that no reaction occurs and that the temperature remains constant, what is the final pressure of the mixture?

A) 25 kPa
B) 50 kPa
C) 100 kPa
D) 150 kPa
E) 200 kPa

ANSWER: calculate number of moles of N2 and O2 assuming constant T = 273 K, add those to get n_{total} and use that number to calculate $P_{total} = n_{total}RT/ V_{final}$

Part 2: Thinking and Investigation **(/17 marks)**

Short answer: Show all your calculations.

10) Assuming that gases behave ideally, if the temperature is 280°C with a pressure of 100.5 kPa, and 15.0 g of ammonium nitrate (NH_4NO_3) decomposes what is the total volume of gas produced? (Hint: ammonium nitrate decomposes into nitrogen, hydrogen, and oxygen gas) **(4 marks)**

ANSWER

Write a balanced chemical equation: $NH_4NO_3 \rightarrow N_2(g) + 2\ H_2(g) + 1/2\ O_2(g)$ <1 mark>

Number of moles NH_4NO_3 = mass/molar mass = 15.0 g/ 80.0 g*mol^{-1} = 0.1875 mol <1 mark>

Ideal gas law: PV = nRT --> V = nRT/P = (0.1875)(8.314)(273+280 K)/(100.5 kPa) = 8.58 L
<2 marks>

11) A 1L steel tank is fitted with a safety valve that opens if the internal pressure exceeds 1.00 x 10^3 torr. It is filled with helium at 23°C and 0.991 atm and placed in boiling water at exactly 100°C. Will the safety valve open? (Hint: 760 torr = 1 atm) **(5 marks)**

ANSWER

"Will the safety valve open?" means "Is P_2 greater than P_1 at T_2?"

P_1 = 0.991 atm (convert to torr)
T_1 = 23°C (convert to K)
V and n remain constant

P_2 = unknown

Name: TEACHER COPY

T_2 = 100°C (convert to K)

Converting T from oC to K: <1 mark>
T_1 (K) = 23°C + 273.15 = 296 K
T_2 (K) = 100°C + 273.15 = 373 K

Converting P from atm to torr:
P_1 (torr) = 0.991 atm x (760 torr/ 1 atm) = 753 torr <1 mark>

Arranging the ideal gas law and solving for P2: At fixed n and V, we have

$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$ or, since n and V are constant, $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

So, $P_2 = P_1 \times \frac{T_2}{T_1} = 753\,torr \times \frac{373\text{K}}{296\text{K}} = 949\,torr$ <2 marks>

1000 torr > 949 torr therefore **the valve will not open**. <1 mark>

12) A tank contains a mixture of gases as follows: 92 g of nitrogen dioxide, 48 g of methane, 64 g of sulfur dioxide, and 64 g of oxygen. Given that the partial pressure of oxygen is 60.0 kPa, find the total pressure of the mixture of gases and the partial pressures of each gas in the tank. **(8 marks)**

$P_{total} = P_{NO2} + P_{CH4} + P_{SO2} + P_{O2}$

$P_{O2} = X_{O2} \times P_{total}$, where X_{O2} is the mole fraction of O_2

Calculate the mole fraction of O_2 by calculating total number of moles in the gas mixture <4 marks>

	Molar mass (g/mol)	Moles	Mole fraction
92 g NO_2	14+16+16 = 46	92/46 = 2	2/8 = 0.25
48 g CH_4	12+1+1+1+1 = 16	48/16 = 3	3/8 = 0.375
64g SO_2	32+16+16 = 64	64/64 = 1	1/8 = 0.125
64g O_2	16+16 = 32	64/32 = 2	2/8 =0.25

$P_{O2} = X_{O2} \times P_{total}$, So: $P_{total} = P_{O2}/ X_{O2}$ = 60.0 kPa/ 0.25 = **240 kPa** is the total pressure <1 mark>

Next, calculate the remaining partial pressures <3 marks>
$P_{NO2} = X_{NO2} \times P_{total}$ = 0.25 x 240 = **60 kPa**
$P_{CH4} = X_{CH4} \times P_{total}$ = 0.375 x 240 = **90 kPa**
$P_{SO2} = X_{SO2} \times P_{total}$ = 0.125 x 240 = **30 kPa**

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Part 3: Communication **(/11 marks)**

13) The following data is for 132 g of $CO_{2(g)}$. The experimental temperature was kept at a constant 55°C. Complete the table, and **graph** your results. Are the results consistent with the Ideal Gas Law? Why or why not? **(7 marks)**

Trial:	1	2	3
Pressure (kPa)	101.3		
Volume (L)		59.85	70.50

ANSWER

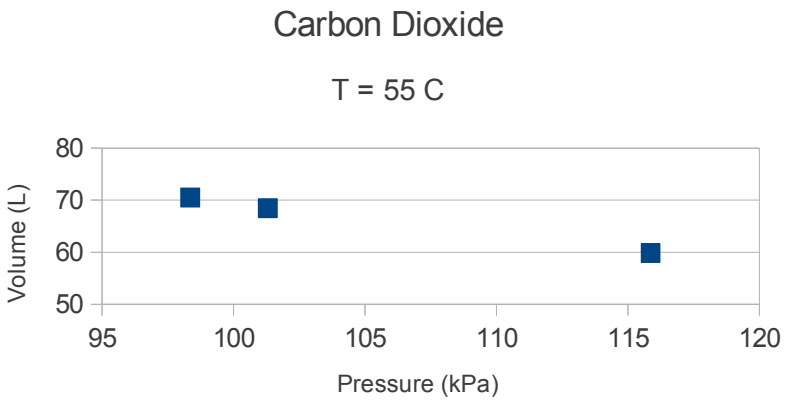
132 g of $CO_{2(g)}$ = 132 g/ 44 g*mol^{-1} = 3 mol <1 mark>

Applying the Ideal Gas law: $P_1V_1 = nRT$ --> $V_1 = nRT/P_1$ = (3)(8.314)(55+273 K)/ 101.3 = 68.45 L <1 mark>

Applying Boyle's law: $P_1V_1 = P_2V_2$ --> $P_2 = P_1V_1/V_2$ = (101.3)(68.45)/ 59.85 = 115.86 kPa
Similarly: $P_3 = P_2V_2/V_3$ = (115.86)(59.85)/ 70.50 = 98.35 kPa <2 marks>

Trial:	1	2	3
Pressure (kPa)	101.3	115.86	98.35
Volume (L)	68.45	59.85	70.50

Sample Scatterplot:
<1 mark for graph>



Discussion: Yes, the experimental results are consistent with the Ideal Gas Law. This is because the ideal gas law shows that pressure and volume are inversely proportional. Assuming that the moles of substance and temperature are held constant, when pressure increases volume decreases and vice versa. <2 marks for explanation>

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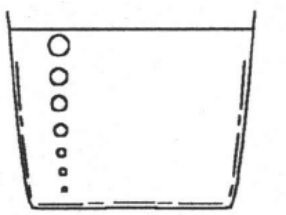
14a) The diagram shows some bubbles rising in a glass of a fizzy drink. Explain why the bubbles get larger as they rise to the surface. (Hint: consider the ideal gas equation) **(3 marks)**



ANSWER

Gas bubbles increase in size as they rise, due to the pressure of the water around them decreasing the higher they are <1 mark> . Because the pressure surrounding the bubbles decreases as they rise this means the gas making up the bubble isn't as compressed therefore the area that the gas fills is greater causing the bubbles to expand <1 mark>. The equation for the deal gas law look like this PV= constant (nRT). If pressure inside the bubble decreases then the volume must increase <1 mark>.

b) What assumption are you making? **(1 mark)**

ANSWER: Assuming that T (temperature) is constant <1 mark>.

Part 4: Application **(/6 marks)**

15) The alkali metals [Group 1A(1)] react with the halogens [Group 7A(17)] to form ionic metal halides. What mass of potassium chloride forms when 5.25 L of chlorine gas at 0.950 atm and 293 K reacts with 17.0 g of potassium? (Hint: R = 0.0821 L atm/ mol K) **(6 marks)**

ANSWER

Write out the balanced equation

$2K(s) + Cl_2(g) \rightarrow 2KCl(s)$ <1 mark>

Summary of gas variables:
P = 0.950 atm
V = 5.25 L
T = 293 K
n = unknown
R = 0.0821 L atm/ mol K

Solving for n_{Cl2} = PV/RT = (0.950)(5.25)/ (0.0821)(293) = 0.207 mol <1 mark>

Next, determine the limiting reactant

If Cl_2 is the limiting reactant: 0.207 mol Cl_2 x (2 mol KCl/ 1 mol Cl_2) = 0.414 mol KCl

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If K is the limiting reactant: 17.0 g K x (1 mol K/ 39.10 g K) = 0.435 mol K
0.435 mol K x (2 mol KCl/ 2 mol K) = 0.435 mol KCl

Since Cl_2 forms less KCl than K, Cl_2 is the limiting reactant <3 marks>

molar mass of KCl = 39.10 + 35.45 = 74.55 g KCl/ mol

Mass of KCl: 0.414 mol KCl/ 74.55 g KCl/ mol = **30.9 g KCl** <1 mark>

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Resources Consulted

Silverberg, Martin S. Chemistry: The Molecular Nature of Matter and Change, 3rd edition. McGraw-Hill 2003

Savita Pall's SCH3U resource website
http://www.savitapall.com/classes/2010_2011/sch3u/index.html

University of Waterloo Chemistry Department webpage
http://uwaterloo.ca/chemistry/about-chemistry/community-outreach/avogadro-past-exams-and-answers