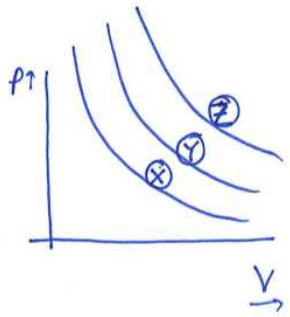
1 Cognitive reasoning in the chemical sciences 2.10

1. **The absent minded professor**

   (a) An absent-minded professor records data on three different ideal gas samples. Sample **A** contains 3 moles of ideal gas and was held at a constant temperature of 400 K. Sample **B** contains 5 moles and was held at a constant temperature of 300 K. Sample **C** contains 4 moles of ideal gas and was held at a constant temperature of 350 K.



   She records the data as shown above. Unfortunately the professor forgets to record which of the three curves goes with which of the three samples. Which curve goes with which sample?

   (b) How would you categorize the above problem? Which of the skills discussed in the first week (proportionality, plug-and-chug, reading graphs, understanding the sizes of numbers, finding synonyms, proportionality constants, a math concept (direct proportionality, indirect proportionality, solving a pair of simultaneous equations, triangle relations. etc...), making pictures in one's mind of a chemical flask, making a picture of the molecules in a flask) were involved? Which subject matter(s) (ideal gases, kinetic theory of gases, effusion, stoichiometry, combustion analysis, limiting reagents) were involved? What did you learn about solving problems in answering this question?

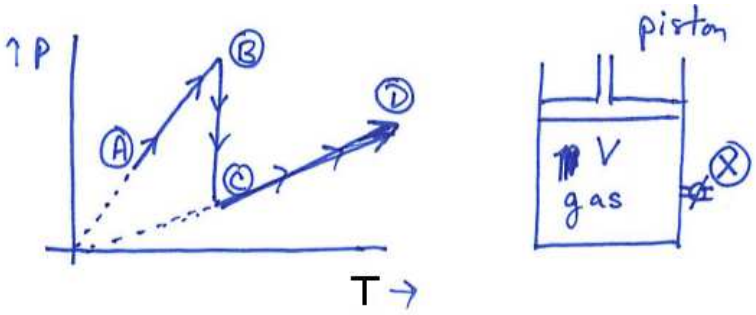
2. **A pair of ballons**

   (a) We have two balloons both at STP. The one contains 4.0 grams of H_2 while the other contains 64.0 g of O_2. Does the hydrogen balloon look bigger, the oxygen balloon look bigger or do the two balloons look the same size?

   (b) How would you categorize the above problem? Which of the skills discussed in the first week (proportionality, plug-and-chug, reading graphs, understanding the sizes of numbers, finding synonyms, proportionality constants, a math concept (direct proportionality, indirect proportionality, solving a pair of simultaneous equations, triangle relations. etc...), making pictures in one's mind of a chemical flask, making a picture of the molecules in a flask) were involved? Which subject matter(s) (ideal gases, kinetic theory of gases, effusion, stoichiometry, combustion analysis, limiting reagents) were involved in this problem? What did you learn about solving problems in answering this question?

3. **A piston**

(a) A piston is shown on the right of the figure below. The piston has a moveable upper wall allowing the volume to change. It also has a valve at the point **X** which can be open or closed. The chamber inside the piston contains an ideal gas. Over the course of an experiment the piston is manipulated so that its p and T travels from point **A** to **B** to **C** and finally to **D** as plotted on the p vs. T plot shown below on the left.



i. Assuming the valve **X** was closed, state an experimental procedure which would have resulted in going from **A** to **B**. In your procedure was the gas was heated (for heating E_{trans} increases) or cooled (for cooling E_{trans} decreases) and did the chamber volume increase, decrease, or was it kept fixed and held at a constant value?

ii. If in going from **B** to **C**, the valve **X** was closed, is the only possible procedure one where temperature was constant and volume was increased?

iii. If in going from **C** to **D**, the valve **X** was open slightly, and gas escaped slowly, what could have been a procedure which would have produced the desired result?

(b) How would you categorize the above problem? Which of the skills discussed in the first week (proportionality, plug-and-chug, reading graphs, understanding numbers, finding synonyms, proportionality constants, a specific math concept, making pictures in one's mind) were involved? Which subject matter(s) (ideal gases, kinetic theory of gases, effusion, stoichiometry, combustion analysis, limiting reagents) were involved in this problem? What did you learn about solving problems in answering this question?

4. **Island hopping** Island hopping refers to the technique used in the solving of chemistry problems in which the student finds the connection between separate islands of information.

(a) A metal M forms an oxide X. X has the empirical formula MO_2 and is 13.38 mass percent oxygen. When heated, X gives off oxygen and converts to Y, which is 9.334 mass percent oxygen. (a) What is the identity of metal M? (b) What is the empirical formula of the compound Y?

(b) How would you categorize the above problem? Which of the skills discussed in the first week (proportionality, plug-and-chug, reading graphs, understanding numbers, finding synonyms, proportionality constants, a specific math concept, making pictures in one's mind) were involved? Which subject matter(s) (ideal gases, gas velocities, effusion, stoichiometry, combustion analysis, limiting reagents) were involved in this problem? What did you learn about solving problems in answering this question?