BEFORE WE GET STARTED

Please register your attendance.

Session 217

SCAN HERE FOR
TYLER ROSTERS

Preparing for the Chemistry Portion of Science

SCIENCE CONTEST 2025

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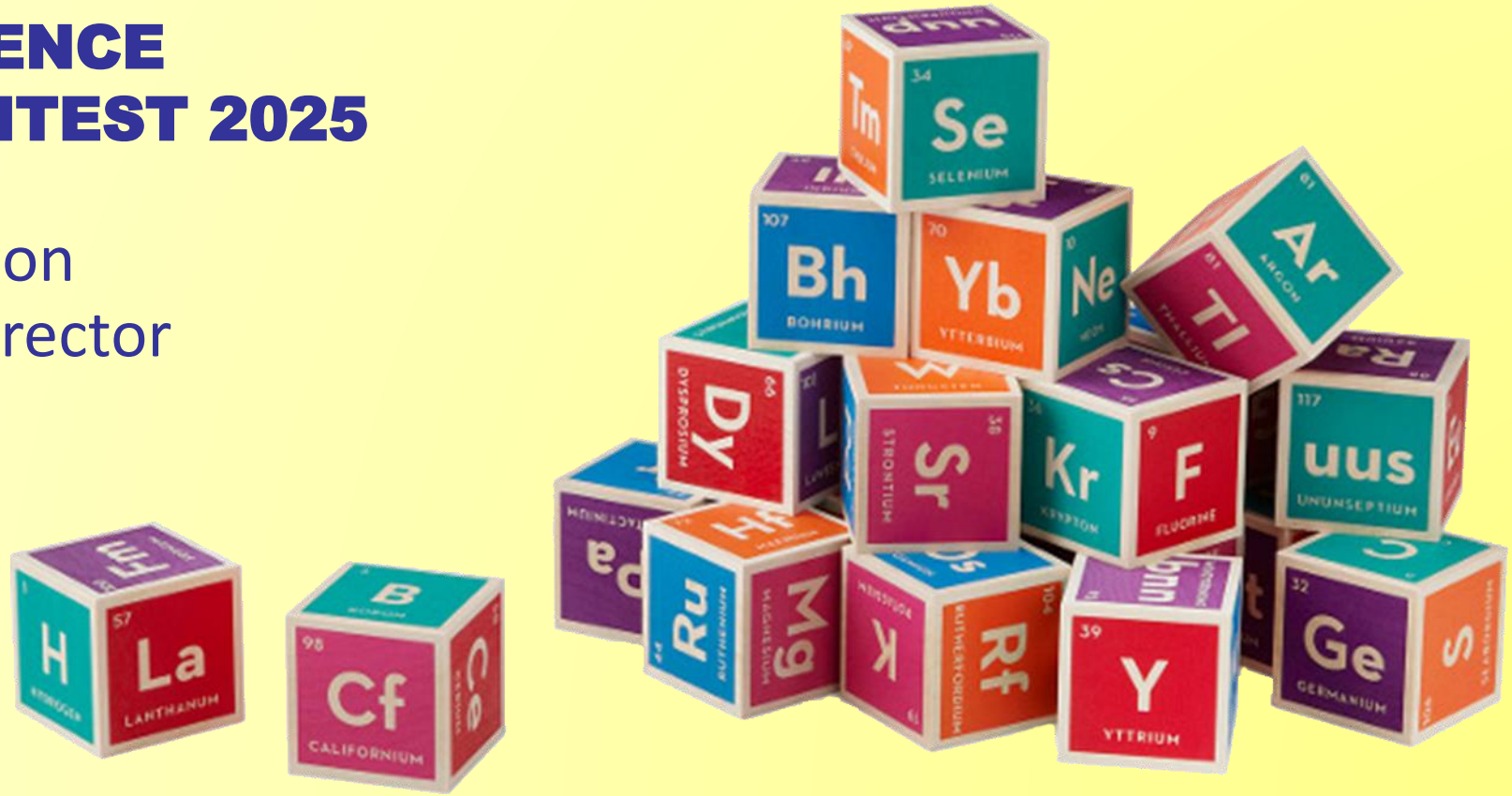
Chemistry Director



UIL Chemistry Exams

- 20 MC questions taken from 13 topic areas
- At least one question from each topic
- Distractors catch common mistakes
- Some real world, situational problems
- Scaled problems get harder with each exam
- Some problems with pictures or graphs
- Has to fit three page, two-column test format

13 topic areas

1. Fundamentals
2. Stoichiometry
3. Atomic Theory
4. Chemical Bonding and Structure
5. Gases
6. Liquids and Solids
7. Thermodynamics
8. Physical Equilibria
9. Chemical Equilibria
10. Acids and Bases
11. Solubility Equilibria
12. Electrochemistry
13. Chemical Kinetics

See the Director's Notes for a full description of each topic area.

Questions in Chemistry

Each exam will have at least one question from each of the 13 topic areas.

Invitationals A & B
Introductory level problems and calculations. Watch for trends in problems! Hint: if you see a definition question here, you're gonna need to know it later…

District
The questions go deeper into the subject matter. Problems become more complex. Some problems present a situation where the pathway to the answer is not immediately apparent.

Regional and State
Problems are longer and more complex than on previous exams. Quantitative problems are multi-step calculations. Sometimes the approach to solving the problem is not obvious, and some critical thinking is involved before the problem can be solved.

Three-page, two-column test format

Plus a removable one-page data sheet.

C01. How many atoms are in one mole of C_6H_{14}?

A) 6.022×10^{23}
B) 1.204×10^{24}
C) 6.022×10^{24}
D) 1.204×10^{25}
E) 6.022×10^{25}

C02. What is the molar mass of gaseous dinitrogen tetroxide?

A) 30.01 g/mol
B) 44.02 g/mol
C) 46.01 g/mol
D) 88.04 g/mol
E) 92.02 g/mol

C03. What is the sum of the coefficients when this chemical equation is balanced?

$$Fe + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2$$

A) 12
B) 9
C) 8
D) 7
E) 4

C04. What is the pH of a 0.0075 M $Ba(OH)_2$ solution?

A) 12.18
B) 11.88
C) 7.5
D) 2.12
E) 1.82

C05. What is the mass percent iron in Fe_2O_3?

A) 30.06%
B) 34.97%
C) 55.85%
D) 69.94%
E) 111.70%

C07. How do the intermolecular forces in solid wax compare to the intermolecular forces in molten wax?

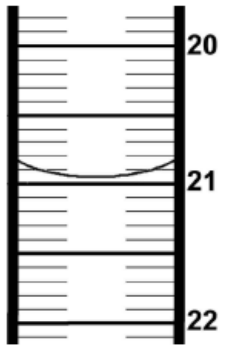
A) Solid wax has hydrogen bonding but molten wax only has dipole-dipole forces.
B) Solid wax has hydrogen bonding but molten wax only has dispersion forces.
C) Solid wax has dipole-dipole attractions, but molten wax only has dispersion forces.
D) Solid wax has dispersion forces and molten wax has no intermolecular forces.
E) The intermolecular forces in solid wax and in molten wax are the same.

C08. What is the net ionic equation for the reaction of lead(II) nitrate with potassium iodide?

A) $2\ PbNO_3(aq) + KI(aq) \rightarrow 2\ PbI(s) + KNO_3(aq)$
B) $Pb_2NO_3(aq) + KI(aq) \rightarrow Pb_2I(s) + KNO_3(aq)$
C) $Pb^{2+}(aq) + 2\ NO_3^-(aq) + 2\ K^+(aq) + 2\ I^-(aq) \rightarrow PbI_2(s) + 2\ KNO_3(aq)$
D) $Pb^{2+}(aq) + 2\ I^-(aq) \rightarrow PbI_2(s)$
E) $K^+(aq) + NO_3^-(aq) \rightarrow KNO_3(s)$

C09. What is the correct volume reading for the liquid in this burette?

A) 20.84 mL
B) 20.96 mL
C) 20.90 mL
D) 21.05 mL
E) 21.16 mL



C10. A piece of silvery metal measuring 2.0 cm × 2.0 cm × 5.0 cm has a mass of 178.60 g. Which of these metals is it most likely to be?

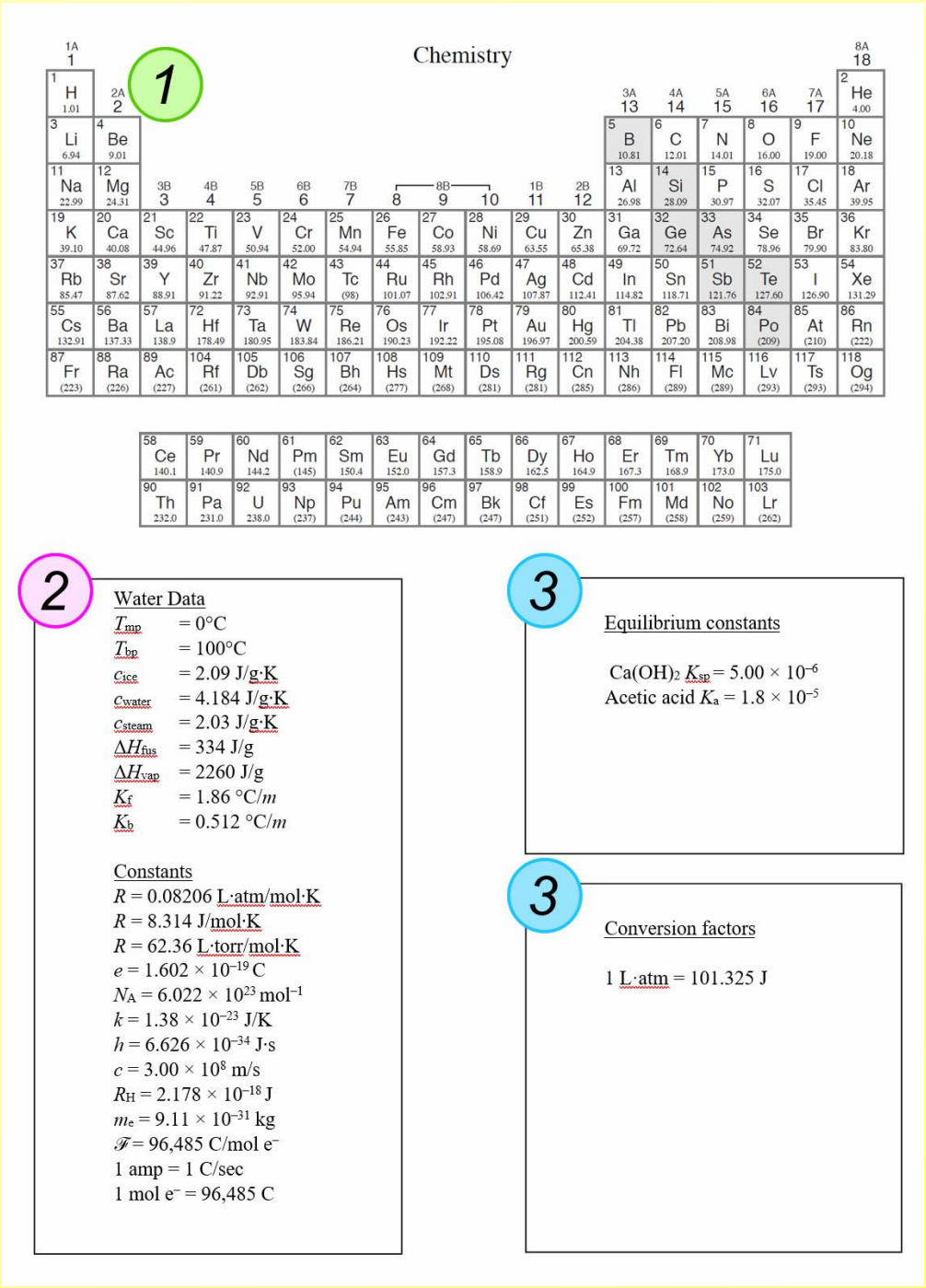
The removable data sheet for Chemistry contains

1 This exact periodic table

2 Water data and commonly used constants.
This is the same on every exam and always includes extra information that is not needed for that exam.

3 Information that is specific to this exam.
Sometimes these boxes will be empty.

I try to include the necessary information in the problem itself, but I don't always have enough space in the test itself to do that.

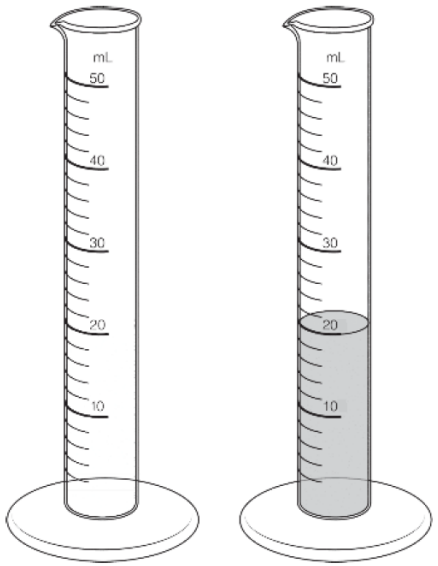


Invitational A through State

- “The same test,” only harder
- Scalable problems
- Increasingly quantitative
- Quantitative problems have more steps

Scalable Problems

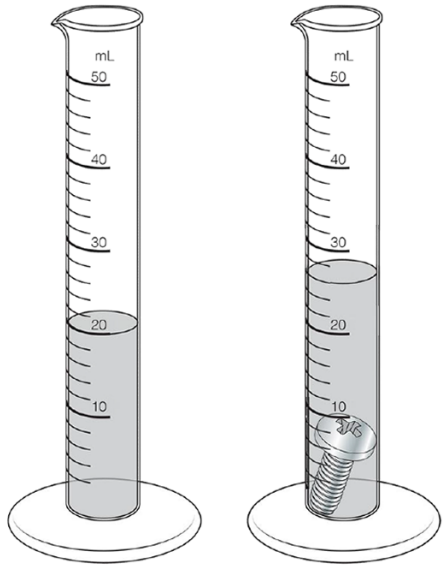
C01. If the empty 50 mL graduated cylinder shown below weighs 177.0 grams and the one with the liquid weighs 204.0 grams, what is the density of the liquid in the graduated cylinder?



A) 1.35 g/mL
B) 1.00 g/mL
C) 1.12 g/mL
D) 10.2 g/mL
E) 0.74 g/mL

Invitational A

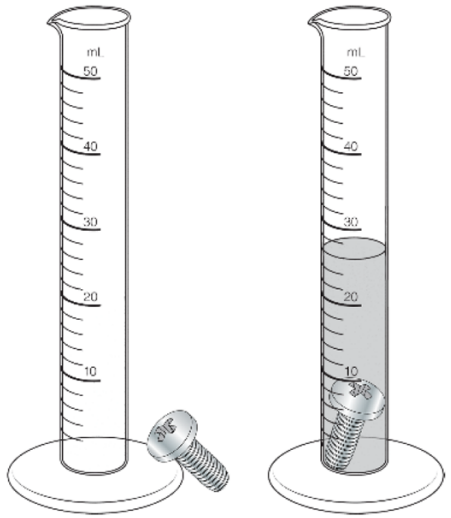
C01. If the graduated cylinder with the liquid in it weighs 204.0 grams and the one with the liquid and the screw weighs 251.1 grams, what is the density of the metal screw inside the graduated cylinder?



A) 9.6 g/mL
B) 7.9 g/mL
C) 6.0 g/mL
D) 8.8 g/mL
E) 8.3 g/mL

Invitational B

C01. The empty graduated cylinder weighs 172.60 grams and the steel screw weighs 51.35 g. If the cylinder containing both the liquid and the screw weighs 248.38 grams, what is the density of the liquid inside the graduated cylinder? The density of the steel screw is 7.9 g/mL.

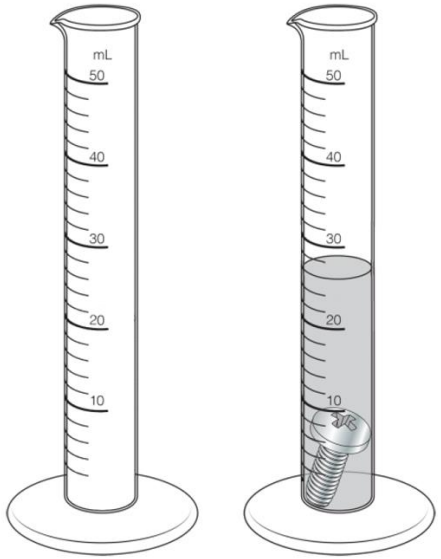


A) 0.79 g/mL
B) 0.92 g/mL
C) 1.00 g/mL
D) 1.14 g/mL
E) 1.25 g/mL

District

Scalable Problems

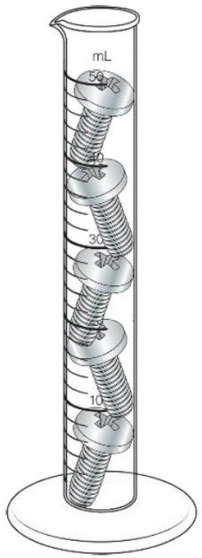
C01. The empty 50 mL graduated cylinder weighs 172.6 grams. If the graduated cylinder with the screw and the liquid has a total mass of 228.0 grams and the screw has a density of 4.9 g/mL, what is the density of the liquid?



A) 0.95 g/mL
B) 1.0 g/mL
C) 1.1 g/mL
D) 1.2 g/mL
E) 1.3 g/mL

Regional

C01. The empty graduated cylinder has a mass of 172.6 grams. Each screw has a density of 5.91 g/mL and a volume of 4.90 mL. Five screws are added to the empty graduated cylinder, and then a liquid with a density of 1.23 g/mL is added to the cylinder. How many mL of the liquid must be added to bring the total mass of the entire system (cylinder, screws, and liquid) to 335.0 g?



A) 17.6 mL
B) 14.3 mL
C) 13.2 mL
D) 11.1 mL
E) 10.5 mL

State

Ways to make problems harder

- Give the chemical name instead of the formula.
- Don't balance the equation.
- Add more steps to a multi-step problem
- Ask about a quantity that doesn't appear explicitly in the equation. For example, PV=nRT includes density, molar mass, and the mass of the sample.

Increasingly quantitative

- Sometimes harder because of the math, sometimes because you need to know a formula, sometimes just because it takes longer
- I don’t like to ask “you know it or you don’t” questions. No trivia questions like “Which element is named after the sun?”
- If I ask a definition, it means you’ll need to know that word or concept on a later test
- Conceptual questions are not necessarily easier

My Process

- Many problems come from questions my students ask in class
- I also look through textbooks and study guides for inspiration
- Problems are never taken directly from a textbook
- All five exams are written simultaneously

Test and solutions deadline:		November 1	December 1	February 1	March 1	April 1
Problem Number		Invitational A	Invitational B	District	Regional	State
1 Fundamentals	Problem written	ϕ	ϕ	ϕ	ϕ	ϕ
	Answer determined					
	Distractors complete					
	Solution written					
2 Stoichiometry	Problem written	ϕ	ϕ	ϕ	ϕ	ϕ
	Answer determined					
	Distractors complete					
	Solution written					
3 Atomic Theory	Problem written	ϕ	ϕ			
	Answer determined					
	Distractors complete					
	Solution written					
4 Chemical Bonding and Structure	Problem written	ϕ	ϕ	ϕ		
	Answer determined					
	Distractors complete					
	Solution written					
5 Gases	Problem written					
	Answer determined					
	Distractors complete					
	Solution written					
6 Liquids and Solids	Problem written			ϕ		
	Answer determined					
	Distractors complete					
	Solution written					
7 Thermodynamics	Problem written	ϕ				ϕ
	Answer determined					
	Distractors complete					
	Solution written					
8 Physical Equilibria	Problem written	ϕ	ϕ	ϕ		
	Answer determined					
	Distractors complete					
	Solution written					
9 Chemical	Problem written				ϕ	
	Answer determined					
	Distractors complete					

Real world situational problems

A student tries to make 1000 mL of 0.500 M $ZnCl_2$ by combining 100 mL of a 5.00 M stock solution with 1000 mL of water. He quickly realizes his mistake, and decides to add more stock solution to the new solution to bring the final concentration to 0.500 M. How much additional stock solution should he add?

A chemist performs a crude titration by dropping NaOH pellets into a 50.0 mL solution of 2.24 M HNO_3 and counting how many pellets it takes to reach the phenolphthalein endpoint. If his NaOH is 96.7% pure and each NaOH pellet weighs 0.1602 grams, how many pellets will he have to add to make the solution turn pink?

Don’t expect to know all the answers

- The test content goes beyond AP Chemistry
- Don’t expect your coaches to know all the answers!
- Some of this I have to look up myself just to be certain
- Step-by-step solutions are provided to coaches at each meet

Solutions for each exam

C10. (B) First calculate how many moles of H^+ are in the acid solution, and how many moles of NaOH are in each pellet:

$$\text{moles of } H^+ = 2.24\ \text{M} \times 0.050\ \text{L} = 0.112\ \text{mol } H^+$$

$$0.1602\ \text{grams/pellet} \times 0.967 \times \frac{1\ \text{mole NaOH}}{40.00\ \text{g}} = 0.003873\ \text{mol NaOH/pellet}$$

Divide the moles of H^+ by the moles per pellet of NaOH to determine how many pellets are required to neutralize the acid:

$$\frac{0.112\ \text{mol } H^+}{0.003873\ \text{mol } OH^-/\text{pellet}} = 28.92\ \text{pellets}$$

So the 29th pellet will result in an excess of NaOH and the solution will turn pink.

C11. (C) Assume a 1000 g sample. In that case the mass of NaCl in the sample is 36.0 g, and the sample volume is (1000 g)/(1.027 g/ml) = 973.7 mL = 0.9737 L.
(36.0 g NaCl)/(58.44 g/mol) = 0.616 mol NaCl
(0.616 mol)/(0.9737 L) = 0.633 M

C12. (A) The two-point Arrhenius equation relates the activation energy and rate constants at two different temperatures:

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{-E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

How to Prepare

- The best book or web site is the one that makes the most sense to the student.
- It doesn’t have to be up to date.
- Understand the concepts, don’t just memorize rules
- Try some YouTube chemistry tutorial videos. Professor Dave Explains, ChemistNATE, Tyler DeWitt, Khan Academy.

Be sure to know these

- Naming compounds from formulas and writing formulas from names
- Calculating moles
- Stoichiometry!
- Using equalities as conversion factors

1. For the reaction

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

Hint: 46 g/mol 18 g/mol 63 g/mol 30 g/mol

What is the maximum amount of HNO_3 that could be formed from 184 g of NO_2 and 27 g of H_2O?

a) 126 g

b) 211 g

c) 94.5 g

d) 25.3 g

e) 168 g

2. Which of the following liquids has the highest vapor pressure?

a) H_2O

b) C_5H_{12}

c) C_2H_5OH

d) $C_{10}H_{12}$

- The liquid with the fewest/weakest intermolecular forces (imfs) will have the highest vapor pressure.
- Small imfs mean faster/easier vaporization rates and higher vapor pressures.
- Water and ethanol both have relatively strong imfs (H-bonding) and therefore have relatively low vapor pressures.
- Pentane and decane both only have dispersion forces which are very weak.
- Overall imf strength scales with molecular size – so decane has stronger imfs than pentane.
- So pentane will have the highest vapor pressure.

3. The heat of combustion (ΔH°) for propane is 2220 kJ/mol. How many kJ of energy are released when 5.00 L of propane at 2.45 atm and 25°C is burned?

a) 1110 kJ

b) 2220 kJ

c) 1875 kJ

d) 555 kJ

e) 3330 kJ

V= **5.00 L**; P = **2.45 atm**; T (in K) = °C + 273.15 = **298.15 K**

use the ideal gas law to get moles of propane

$n = PV/RT = (2.45 \times 5.00)/(0.08206 \times 298.15) = 0.500$ mol

$0.500 \text{ mol} \times 2220 \text{ kJ/mol} = 1110 \text{ kJ}$

THANK YOU FOR ATTENDING

Tyler Eval

We value your feedback.

Please complete conference evaluation after your last session.

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