

ASSIGNMENT MARK: out of 24
TA INITIALS

STEM 372 opposite, cabinet have name of prof and
there is PHY 1321/1331 A/B

ASSIGNMENT 1:
Pressure, Temperature,
Ideal Gas Equation.

UNIVERSITY OF OTTAWA
Principles of Physics
PHY1321/31 Fall 2018
Dr. A. Czajkowski

STUDENT #: 30008853

LAST NAME: KIM

Signature: _____

Released: Sept 14

Due: Sept 21 6PM

Each question is marked out of 4 points, In addition to this there are 4 points for presentation/aesthetics for the whole assignment

- 1 HS teacher duplicated Torricelli's barometer using a mineral oil, of density 1230 kg/m^3 , as the working liquid. What was the height h of the oil column for normal atmospheric pressure?

Vacuum $P=0$
density $\rho = 1230 \text{ kg/m}^3$

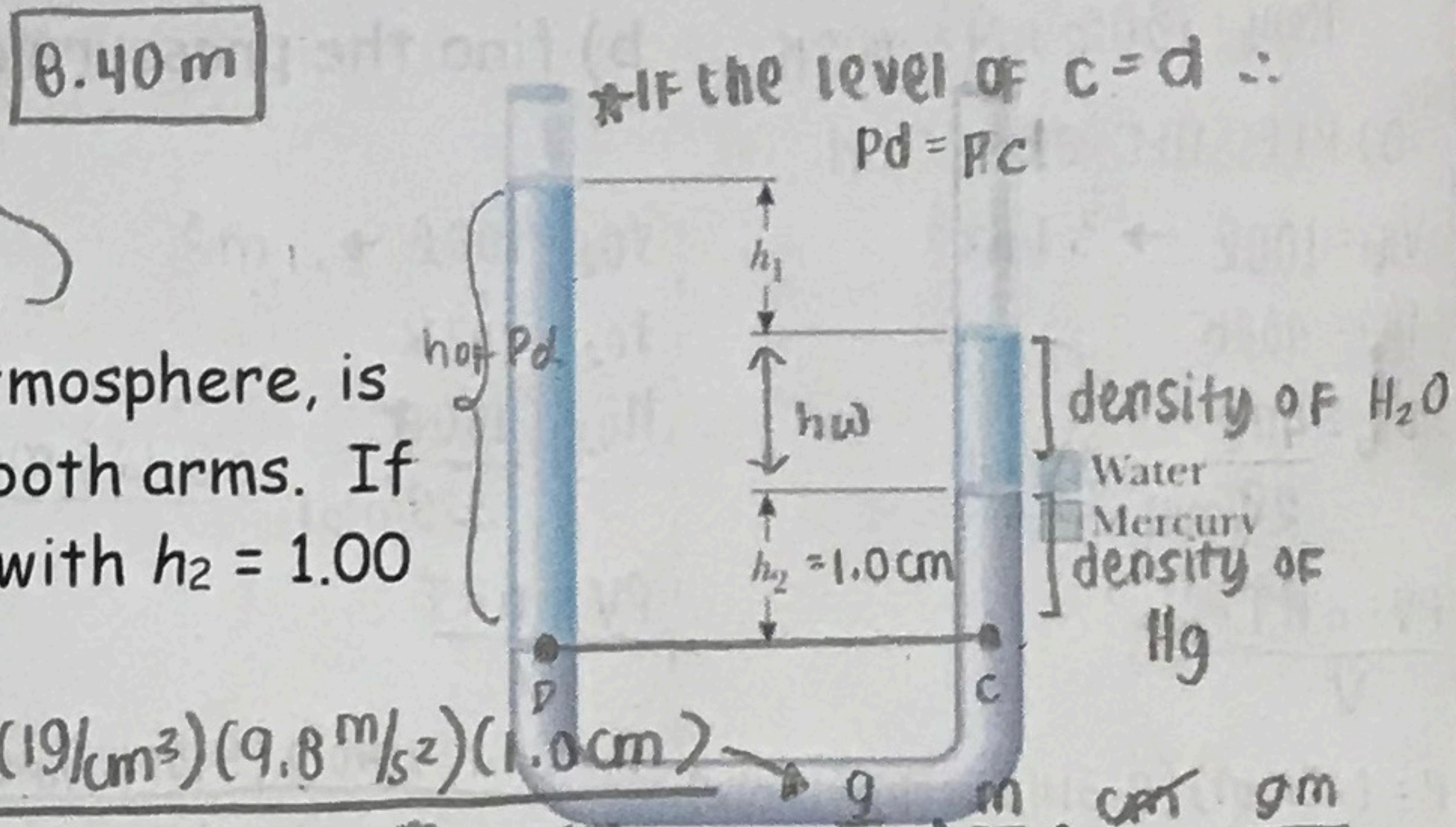
$$P = P_0 + \rho gh$$

$$101300 \text{ Pa} = 0 + (1230 \text{ kg/m}^3)(9.8 \text{ m/s}^2)h$$

$$h = \frac{101300 \text{ Pa}}{(1230 \text{ kg/m}^3)(9.8 \text{ m/s}^2)} \rightarrow \frac{\text{kg}}{\text{m}^3} \cdot \frac{\text{m}}{\text{s}^2} = \text{kg/s}^2$$

$$h = \frac{101300 \text{ Pa}}{12054 \text{ kg/s}^2} \rightarrow P_0 = \text{kg/ms}^2$$

$$h = \frac{101300 \text{ kg/ms}^2}{12054 \text{ kg/s}^2} \rightarrow \frac{\text{kg}}{\text{ms}^2} \cdot \frac{\text{s}^2}{\text{kg}} = \text{m}$$



- 2 A U-tube of uniform cross-sectional area, open to the atmosphere, is partially filled with mercury. Water is then poured into both arms. If the equilibrium configuration of the tube is as shown in, with $h_2 = 1.00 \text{ cm}$, determine the value of h_1 .

density $Hg = 13.6 \text{ g/cm}^3$
density $H_2O = 1 \text{ g/cm}^3$

$$P_d = P_c \rightarrow P_c = P_{atm} + \rho gh$$

$$\text{IST SOLVE } P_c = P_{atm} + \rho g(h_2) + \rho g(h_w)$$

$$P_d = P_{atm} + \rho gh$$

$$P_d = P_{atm} + \rho g(h_1 + h_w + h_2)$$

$$h_1 = \frac{(13.6 \text{ g/cm}^3)(9.8 \text{ m/s}^2)(1.00 \text{ cm}) - (1 \text{ g/cm}^3)(9.8 \text{ m/s}^2)(1.00 \text{ cm})}{(9.8 \text{ m/s}^2)}$$

$$h_1 = \frac{(133.28 \text{ g/cm}^2 \cdot \text{s}^2) - (9.8 \text{ g/cm}^2 \cdot \text{s}^2)}{9.8 \text{ g/cm}^2 \cdot \text{s}^2} = \frac{123.48 \text{ g/cm}^2 \cdot \text{s}^2}{9.8 \text{ g/cm}^2 \cdot \text{s}^2}$$

$$\Rightarrow P_{atm} + \rho g(h_1 + h_w + h_2) = P_{atm} + \rho g(h_2) + \rho g(h_w)$$

$$\frac{\rho g(h_1 + h_w + h_2)}{\text{water}} = \frac{\rho g(h_2)}{Hg} + \frac{\rho g(h_w)}{\text{water}}$$

$$\rho_w g(h_1) + \rho_w g(h_w) + \rho_w g(h_2) = \rho_{Hg} g(h_2) + \rho_w g(h_w)$$

$$\rho_w g(h_1) + \rho_w g(h_2) = \rho_{Hg} g(h_2)$$

$$\rho_w g(h_1) = \rho_{Hg} g(h_2) - \rho_w g(h_2)$$

$$h_1 = \frac{\rho_{Hg} g(h_2) - \rho_w g(h_2)}{\rho_w g}$$

$h_1 = 12.6 \text{ cm}$

- 3 a) Show that 1 mole of any gas at atmospheric pressure and at 0°C is taking 22.4 liters of volume

Given: $T = 0 + 273 = 273 \text{ K}$

- (b) Show that the density of an ideal gas occupying a volume V is given by $\frac{PM}{RT}$ where M is the molar mass.

$$0) PV = nRT$$

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

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

$$V = \frac{(1 \text{ mol})(8.314 \text{ J/mol} \cdot \text{K}) 273 \text{ K}}{101300 \text{ Pa}}$$

$V = 0.02240 \text{ m}^3 = 22.40 \text{ L}$

$$b) \rho = \frac{m}{V} \quad V = \frac{m}{\rho}$$

$$PV = nRT$$

$$\text{sub } V \rightarrow P \left(\frac{m}{\rho} \right) = nRT$$

$$\frac{m}{\rho} = \frac{nRT}{P}$$

$$mP = \rho nRT$$

$$\rho = \frac{mP}{nRT}$$

$$n = \frac{m}{M} \therefore M = \frac{m}{n}$$

$$P = \frac{MP}{RT}$$

c) $P_{O_2} = \frac{(0.022 \text{ kg/mol})(101300 \text{ kg/ms}^2)}{(8.314 \text{ J/mol})(273 \text{ K})}$

$$P_{O_2} = \frac{3241.60 \text{ kg}^2/\text{mol} \cdot \text{ms}^2}{2436.002 \text{ J/mol} \cdot \text{K}}$$

$$P_{O_2} = 1.33 \text{ kg/m}^3$$

$$\frac{\text{kg}^2}{\text{mol} \cdot \text{kg}} = \text{kg} \cdot \frac{\text{m}}{\text{kg}}$$

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ASSIGNMENT 1: CONT

4 100 grams of oxygen and 40 grams hydrogen gas occupy separate, equal sections of 200 liter tank. The divide is removed and the gases are allowed to mix and react with each other. The temperature is kept constant at 130 °C, throughout the process

Given:
100g O₂ } occupy separate, but
40g H₂ } share equally
200L tank

T_{cons} = 130°C + 273 = 403K

a) find the pressure of each gas in the separate containers

b) find the pressure after the reaction ends.

0) PRESSURE OF EACH

V_{H₂} = 100L → .1 m³

T_{H₂} = 403K

n_{H₂} = $\frac{40g}{2g/mol} = 20 \text{ mol}$

PV = nRT

P = $\frac{(20 \text{ mol})(8.314 \text{ J/mol}\cdot\text{K})(403 \text{ K})}{.1 \text{ m}^3}$

P_{H₂} = 670148.7 J/m³ OR Pa

OR
P_{H₂} = 670.15 KPa

V_{O₂} = 100L → .1 m³

T_{O₂} = 403K

n_{O₂} = $\frac{100g}{32g/mol} = 3.125 \text{ mol}$

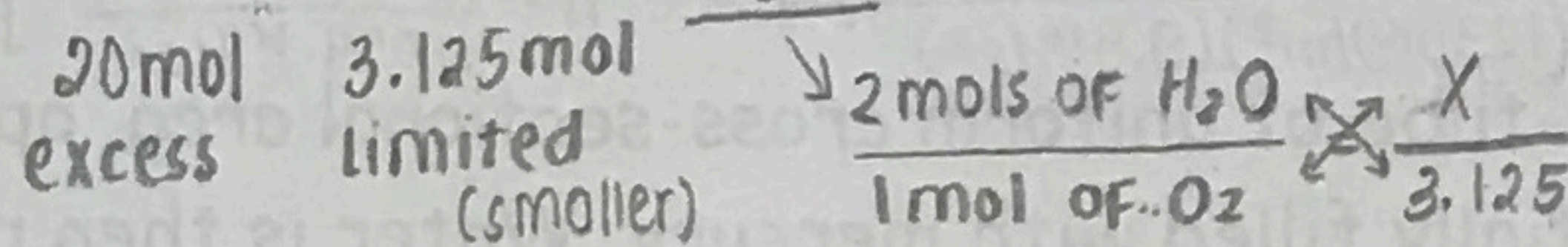
PV = nRT

P = $\frac{(3.125 \text{ mol})(8.314 \text{ J/mol}\cdot\text{K})(403 \text{ K})}{.1 \text{ m}^3}$

P_{O₂} = 104704.44 J/m³ OR Pa OR

P_{O₂} = 104.70 KPa

b) pressure after the reaction ends. (P_{H₂O})



V = .2 (combined) m³ = (3.125 mol O₂) (2 mol H₂O) - (X mol H₂O) (1 mol O₂)

X = 6.25 = n
mol of ↑ H₂O

PV = nRT

P_{H₂O} = $\frac{nRT}{V}$

P_{H₂O} = $\frac{(6.25 \text{ mol})(8.314 \text{ J/mol}\cdot\text{K})(403 \text{ K})}{.2 \text{ m}^3}$

P_{H₂O} = 104704.44 J/m³ OR Pa OR 104.70 KPa

pressure of excess H₂

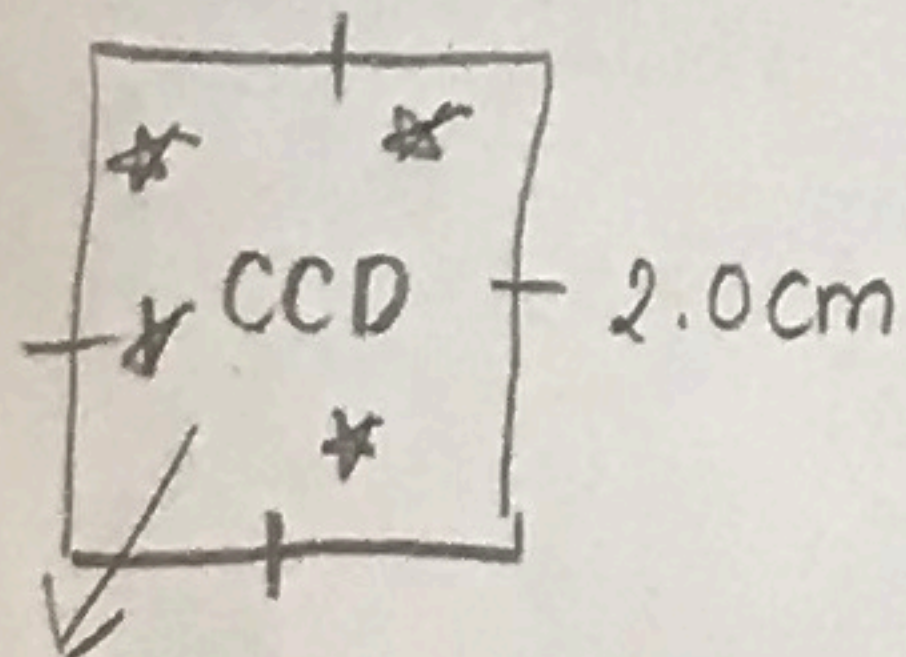
P_{H₂} = $\frac{(20 \text{ mol} - 6.25 \text{ mol})(8.314 \text{ J/mol}\cdot\text{K})(403 \text{ K})}{.2 \text{ m}^3}$

P_{H₂} = 230349.76 J/m³
= 230.35 KPa

but H₂ excess + H₂O

= 104.70 KPa + 230.35 KPa
= 335.05 KPa

5 A telescope forms an image of part of a cluster of stars on a square silicon charge-coupled detector (CCD) chip 2.00 cm on each side. A star field is focused on the CCD when it is first turned on and its temperature is 27.0°C. The star field contains 5432 stars scattered uniformly. To make the detector more sensitive, it is cooled to -173°C. How many star images then fit onto the chip? The average coefficient of linear expansion of silicon is 4.68 × 10⁻⁶ (°C)⁻¹. Find Δ stars



see stars 5432

Given: A_i = 2² = 4 cm²

T_i = 27°C

T_f = -173°C

CCD expand = 4.68 × 10⁻⁶ (°C)⁻¹

ΔC = $\frac{4.68 \times 10^{-6}}{1}$
y = α ΔT

ΔA = A_f - A_i

= γ(T_f - T_i)A_i

= γA_iΔT

ΔA = 2α A_iΔT → (T_f - T_i) = -200 °C

ΔA = 2(4.68 × 10⁻⁶ / °C) (4 cm²) (-200 °C)

ΔA = -.007488 cm²

ΔA = A_f - A_i

A_f = ΔA + A_i

A_f = -.007488 cm² + 4 cm²

A_f = 3.992512 cm²

new area

stars

Area

$\frac{5432 \text{ stars}}{4 \text{ cm}^2} = \frac{X}{3.99 \text{ cm}^2}$

4 cm² X = (5432 stars)(3.992512 cm²)

X = $\frac{21687.3298 \text{ stars}}{4}$

X = 5421.83

∴ X = 5421 full stars