pn

THE DIAGRAM SHOWS HOW THE STREAM OF WATER EMERGING FROM A FAUCET NECK DOWN AS IT FALLS. THE INDICATED CROSS SECTIONAL AREAS ARE $A_0 = 1.2\ cm^2$ AND $A = 0.35\ cm^2$. THE TWO LEVELS ARE SEPARATED BY A VERTICAL DISTANCE $h = 45\ mm$. WHAT IS THE VOLUME FLOW RATE FROM THE TAP?

VOLUME FLOW RATE (R_V)

$$R_V = A_0 V_0$$

$$V_0 = ?$$

$$\boxed{A_0 V_0 = A V}$$

$$V^2 = V_0^2 + 2gh$$

$$\boxed{V_0 = \sqrt{\frac{2gh\, A^2}{A_0^2 - A^2}}}$$

$$V_0 = \sqrt{\frac{2 \times 9.81 \times \frac{45}{1000} \times (0.35)^2}{(1.2)^2 - (0.35)^2}}$$

$$= 0.286\ m/s$$

$$R_V = 1.2\ cm^2 \times 28.6\ cm/s$$

$$= 34\ cm^3/s$$

pn A

WHERE

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WAVE

WHAT

ON T

R EMERGING
NDICATED
$= 0.35 cm^2$.
DISTANCE
THE TAP?

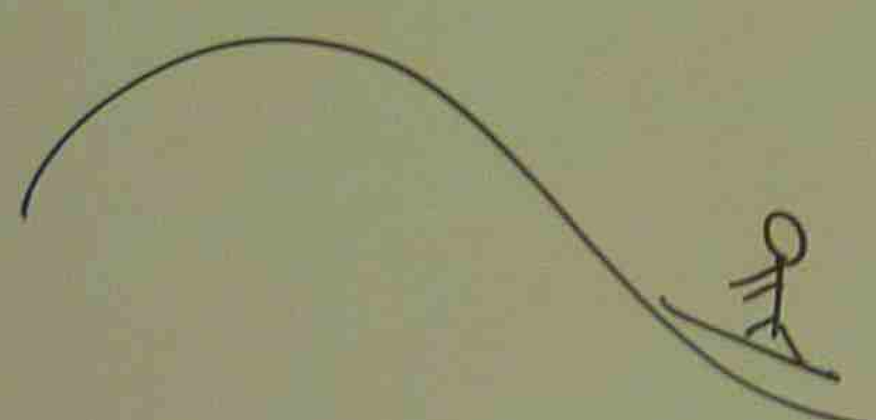
$R_V = 1.2 \times \dfrac{28.6\ cm/s}{cm^2}$

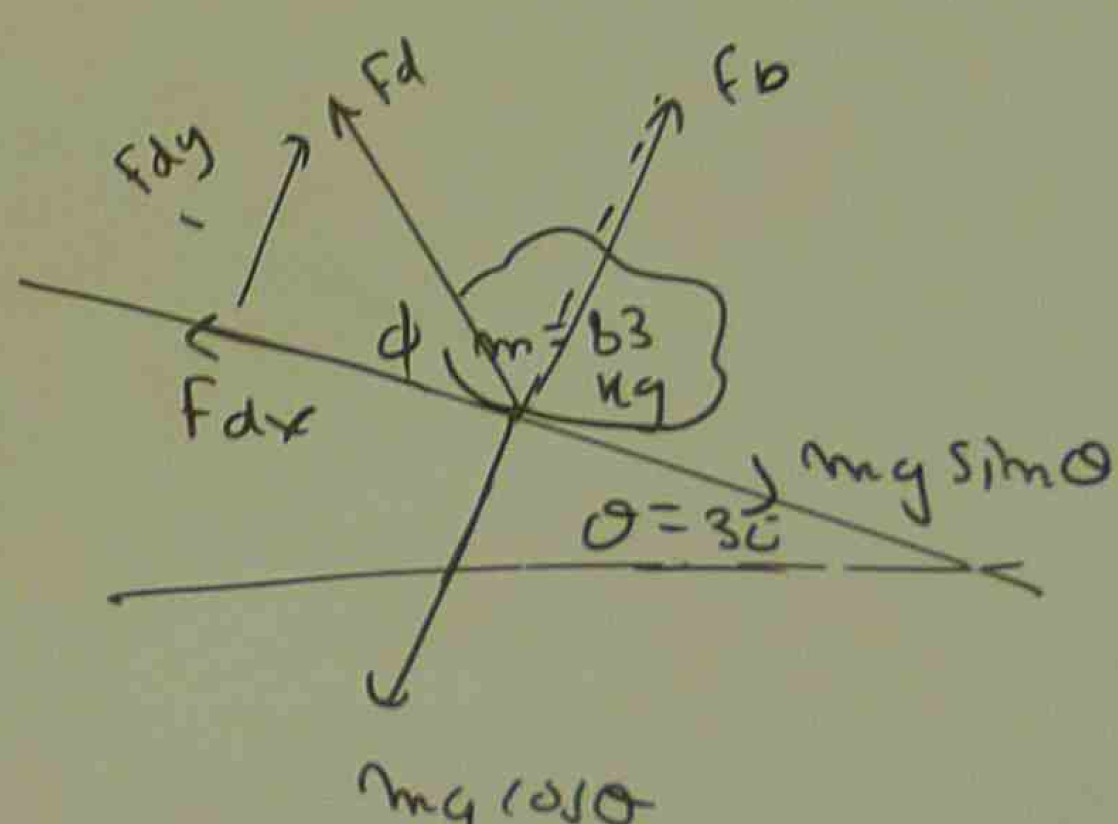
$= 34\ cm^3/s$

$(0.35)^2$

$)^2$

P1) A SURFER RIDES ON THE FRONT SIDE OF A WAVE AT A POINT WHERE A TANGENT TO THE WAVE HAS A SLOPE OF $\theta = 30°$. THE COMBINED MASS OF SURFER AND SURFBOARD IS $m = 83$ kg. THE BOARD HAS A SUBMERGED VOLUME OF $V = 2.5 \times 10^{-2}\ m^3$. THE SURFER MAINTAINS HIS POSITION ON THE WAVE AS THE WAVE MOVES AT CONSTANT SPEED TOWARD SHORE. WHAT ARE THE MAGNITUDE AND DIRECTION OF THE DRAG FORCE ON THE SURF BOARD FROM THE WATER?





F_b = WATER FORCE $= m_f g = \rho V g$

$= (1.024 \times 10^3\ kg/m^3) \times 2.5 \times 10^{-2} \times 9.8\ m/s^2$

$= 2.509 \times 10^2\ N$

Fdy +

Fdy + 2.

Fd

Fdx =

=

=

F -

AT A POINT

$\theta = 30°$

$m = 83$ kg.

2.5×10^{-2} m^3

AS THE

DRAG FORCE

$mg \sin\theta$

10^3 kg/m^3) $\times 2.5 \times 10^{-2} \times 9.8$ m/s^2

$\ldots 09 \times 10^2$ N

$f_{dy} + f_b = mg\cos\theta$

$f_{dy} + 2.509 \times 10^2 = 83 \times 9.8 \cos 30$

$f_{dy} = 435.5$ N

$f_{dx} = mg \sin\theta$

$= 83 \times 9.81 \sin 30$

$= 406.7$ N

$F = \sqrt{f_{dx}^2 + f_{dy}^2}$

$= \sqrt{406.7^2 + 435.5^2}$

$= 595.8$ N

THERMAL EXPANSION

LINEAR EXPANSION

$\boxed{\Delta L = L \alpha \Delta t}$

L = ORIGINAL LENGTH

α = COEFFICIENT OF LINEAR EXPANSION

Δt = CHANGE OF TEMPERATURE

VOLUME EXPANSION

$\Delta V = V \beta \Delta t$

V = ORIGINAL VOLUME

β = COEFFICIENT VOLUMETRIC EXPANSION

$\beta = 3\alpha$

AREA E…

$\Delta A = $

$r = $

Pb on…

LOADE…

COLD

WAS 2

HOW M…

VOLUM…

COEFF…

...ERMAL EXPANSION

...R EXPANSION

$\boxed{\ldots \alpha \Delta t}$

...RIGINAL LENGTH
...EFFICIENT OF LINEAR EXPANSION
...HANGE OF TEMPERATURE

... EXPANSION

$\ldots \beta \Delta t$

...RIGINAL VOLUME
...FFICIENT VOLUMETRIC
...PANSION

$= 3\alpha$

AREA EXPANSION

$$\Delta A = A \gamma \Delta t$$

$$\gamma = 2\alpha$$

Pb ON A HOT DAY IN LAS VEGAS, AN OIL TANKER LOADED 37000 L OF DIESEL FUEL. IT ENCOUNTERS COLD WEATHER ON UTAH WHERE TEMPERATURE WAS 23 K LOWER THAN IN LAS VEGAS. HOW MANY LITERS DID IT DELIVER?
VOLUME EXPANSION FOR DIESEL FUEL IS $9.5\times10^{-4}/^{\circ}C$
COEFFICIENT OF LINEAR EXPANSION IS $11\times10^{-6}/^{\circ}C$

$$\Delta V = V \beta \Delta T$$
$$= (37000\,L)\times(9.5\times10^{-4})\times(-23)$$
$$= -808\ L$$

$$V_{deL} = V + \Delta V = 37000 + (-808)$$
$$= 36190\ L$$

TEMPERATURE A...

HEAT IS THE ENERG...
BECAUSE OF A TEMPE...

$1\ cal = 3\ldots$

HEAT ABSORPTION

$Q = C \Delta T\ldots$
$C = m\, c\ldots$

$\boxed{Q = m\ldots}$

MOLAR SP...

SPECIFYI...
mole

OIL TANKER
IT ENCOUNTERS
TEMPERATURE
S.
?
IS $9.5 \times 10^{-4}/c$
S $11 \times 10^{-6}/c$
T
$9.5\times10^{-4}) \times (-23)$
$000 + (-808)$
G190 L

TEMPERATURE AND HEAT

HEAT IS THE ENERGY TRANSFERRED BETWEEN A SYSTEM AND IT'S ENVIRONMENT. BECAUSE OF A TEMPERATURE DIFFERENCE THAT EXISTS BETWEEN THEM.

$$1\ cal = 3.968 \times 10^{-3}\ BTU = 4.1868\ J$$

HEAT ABSORPTION / HEAT CAPACITY

$$Q = C \Delta T = c(T_f - T_i)$$

$$C = m c$$

c = SPECIFIC HEAT CAPACITY

$= 4190\ J/kg\,K$

m = MASS (kg)

$$\boxed{Q = mc\Delta t = mc(T_f - T_i)}$$

MOLAR SPECIFIC HEAT

SPECIFYING THE AMOUNT OF SUBSTANCE

mole (mol) $\quad 1\ mol = 6.02 \times 10^{23}$ ELEMENTARY UNITS

HEAT OF TRANSFO

SOLID ⟶ LIQUID
0°C $\quad$ 0°C

LIQUID ⟶
100°C

AMOUNT OF HEAT REQU
THE STATE ⟶ LA

Pb HOW MUCH HEAT MUST BE A
MASS m = 720 g AT −10°C
STATE AT 15°C?

I ICE

−10°C ICE ⟶ 0°C ICE
CHANGE OF TEMPERATU
↓
HEAT ABSORBED

$Q_1 = m_{ICE} \times C_{ice} \times \Delta$

WATER

III CHANGE OF TEMPERAT

$Q_3 = m_{WATER}\, C_{WA}$

... A SYSTEM AND IT'S ENVIRONMENT.
...HAT EXISTS BETWEEN THEM.

...68 J

HEAT OF TRANSFORMATION

SOLID $\longrightarrow$ LIQUID
$0^\circ C$ $\quad$ $0^\circ C$

LIQUID $\longrightarrow$ VAPOR
$100^\circ C$ $\quad$ $100^\circ C$

AMOUNT OF HEAT REQUIRED FOR CHANGING THE STATE $\longrightarrow$ LATENT HEAT.

Pb HOW MUCH HEAT MUST BE ABSORBED BY ICE OF MASS $m = 720\,g$ AT $-10^\circ C$ TO TAKE THE LIQUID STATE AT $15^\circ C$?

I ICE

$-10^\circ C$ ICE $\longrightarrow$ $0^\circ C$ ICE

CHANGE OF TEMPERATURE
$\downarrow$
HEAT ABSORBED

$$Q_1 = m_{ICE} \times C_{ice} \times \Delta t$$

II ICE $\rightarrow$ WATER
CHANGE OF STATE

$0^\circ C$ ICE $\longrightarrow$ $0^\circ C$ WATER

$$Q_2 = m_{ICE} L$$

WATER

III CHANGE OF TEMPERATURE

$$Q_3 = m_{WATER} C_{WATER} \Delta t$$

$$Q_t = Q_1 + Q_2 + Q_3$$

$$= m_{ICE} C_{ICE} \Delta t + m_{ICE} L + m_{WATER} C_{WATER} \Delta t$$

$$= \frac{720}{1000} kg \times 2220\, J/kgK \times (0-(-10))$$

$$+ \frac{720}{1000} (333\, kJ/kgK)$$

$$+ \frac{720}{1000} \times 4190\, kJ/kgK \times (15-0)$$

$$\approx 300\, kJ$$

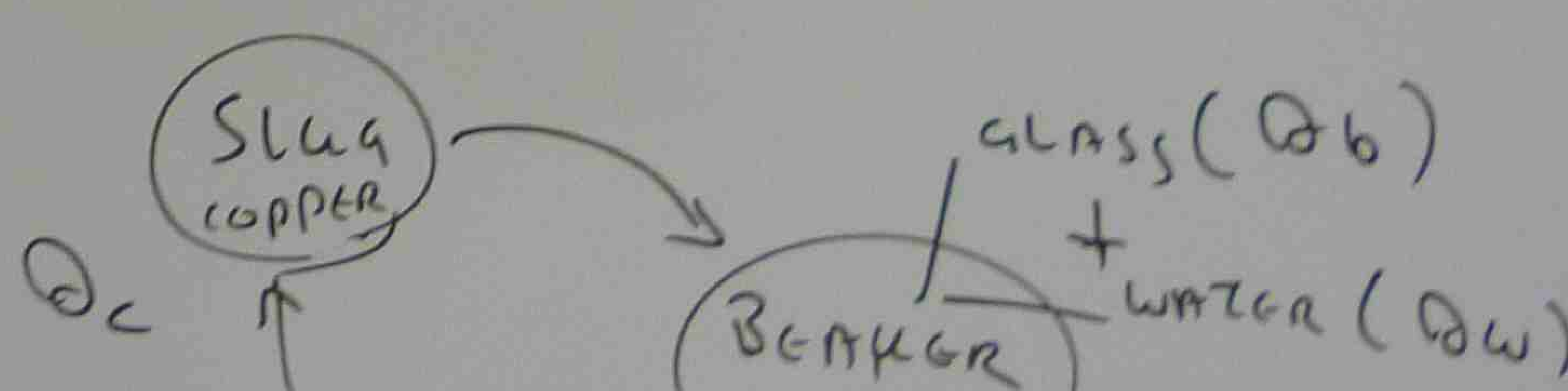
T_i)

...TANCE

$...2\times10^{23}$ ELEMENTARY UNITS

Pn

A copper slug whose mass m_c is 75 g is heated in a laboratory oven to a temperature T of 312°C. The slug is then dropped into a glass beaker containg mass $m_w = 220\,g$ of water. The heat capacity C_b of the beaker is 45 cal/K. The initial temperature T_i of the water and the beaker is 12°C. Assuming that the slug, beaker and water are an isolated system and the water does not vaporize. Find the final temperature T_f of the system at thermal equilibrium.



$$Q_w + Q_b + Q_c = 0$$

$Q_w = C_w m$

$Q_b = C_b$

$Q_c = c_c$

$T_f = \frac{c_c}{}$

$= \frac{0.}{1.}$

$=$

MASS m_c IS 75 g IS
Y OVEN TO A TEMPERATURE
THEN DROPPED INTO A GLASS
m_w = 220 g OF WATER.
OF THE BEAKER IS 45 cal/°K
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ASSUMING THAT THE SLUG,
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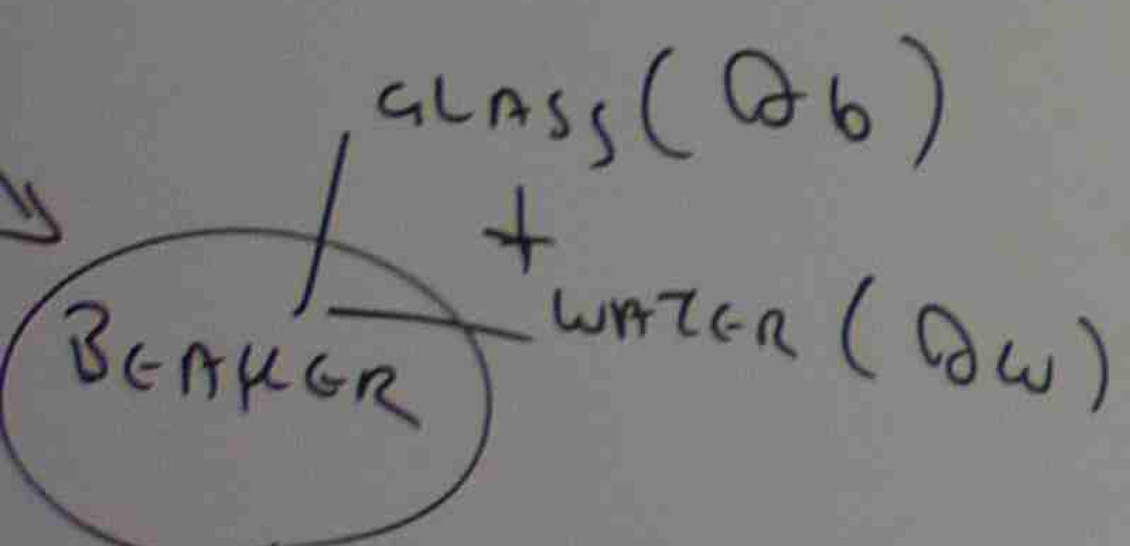


$$Q_b + Q_c = 0$$

$$Q_w = c_w m_w (T_f - T_i)$$

$$Q_b = C_b (T_f - T_i)$$

$$Q_c = c_c m_c (T_f - T_i)$$

$$T_f = \frac{c_c m_c T + C_b T_i + c_w m_w T_i}{c_w m_w + C_b + c_c m_c}$$

$$= \frac{0.0923 \times 75g \times 312 + 45 \times 12 + 1.00 \times 220g \times 12C}{1.00 \times 220 + 45 + 0.0923 \times 75}$$

$$= 20°C$$

GASE

$$\boxed{PV = m}$$

K = BOLTZMAN

mR =

$$\boxed{PV =}$$

WORK DONE

V_1

INITIAL VO

GASES

$$\boxed{PV = mRT}$$

P = PRESSURE

V = VOLUME

R = GAS CONSTANT

T = TEMPERATURE

$$K = \text{BOLTZMANN CONSTANT} = \frac{R}{N} = \frac{8.31 \ J/mol\text{-}K}{6.02 \times 10^{23} \ mol^{-1}} = 1.38 \times 10^{-23} \ J/K$$

$$mR = NK$$

$$\boxed{PV = NKT}$$

WORK DONE BY THE GAS AT CONSTANT TEMPERATURE

$$V_i \xrightarrow{W} V_f$$

V_i = INITIAL VOLUME

V_f = FINAL VOLUME

$$W = nRT \ln \frac{V_f}{V_i}$$

(J)

$m_w T_i$

m_c

x 12 + 1.00 x 220g x 12 c

23 x 75

pb A CYLINDER

THE TEMPERATURE

8.5 L. WHAT IS

$$PV = mRT$$

$$\frac{PV}{T} = \underbrace{mR}_{\text{CONSTANT}}$$

pb ONE MOLE OF

310 K FROM AN

V_f of 19 L.

...T

...URE

$k = 1.38 \times 10^{-23}$ J/K

...EMPERATURE

$...RT \ln \frac{V_f}{V_i}$

pb A CYLINDER CONTAINS 12 L OF OXYGEN AT 20°C AND 15 atm. THE TEMPERATURE IS RAISED TO 35°C AND THE VOLUME IS REDUCED TO 8.5 L. WHAT IS THE FINAL PRESSURE OF THE GAS IN ATMOSPHERE

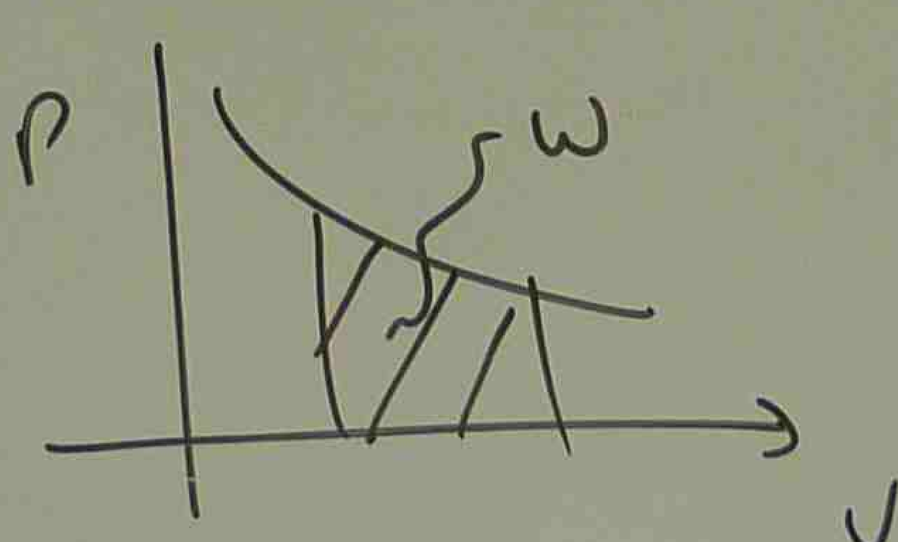
$$PV = nRT$$

$$\frac{PV}{T} = \underbrace{nR}_{\text{CONSTANT}}$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{15 \times 12}{(20+273)} = \frac{P_2 \times 8.5}{(35+273)} \rightarrow P_2 = 22 \text{ atm}$$

pb ONE MOLE OF OXYGEN EXPANDS AT A CONSTANT TEMPERATURE T OF 310 K FROM AN INITIAL VOLUME V_i OF 12 L TO A FINAL VOLUME V_f OF 19 L. HOW MUCH WORK IS DONE BY THE GAS DURING EXPANSION?



$$W = nRT \ln \frac{V_f}{V_i}$$

$$= (1\,\text{mol}) \times 8.31\ \text{J/mol·K} \times 310 \ln \frac{19}{12}$$

$$= 1180\ \text{J}$$

pb THE m...

(a) WHAT I...

(b) WHAT I...

(c) WHAT ...

(a) $V_{avg} = ...$

(b) V_{rms} ...

(c) $V_p = ...$

T 20°C AND 15 atm.
THE volume IS REDUCED TO
GAS IN ATMOSPHERE

$P_2 = 22$ atm

T TEMPERATURE T of
L TO A FINAL volume
THE GAS DURING EXPANSION?

$T \ln \frac{V_f}{V_i}$

$) \times 8.31\ J/_{mol \cdot K} \times 310 \ln \frac{19}{12}$

30 J

PN THE molAR MASS M of OXYGEN IS 0.0320 kg/mol THE molAR MASS M of OXYGEN IS 0.0320 kg/mol

Pn THE molAR MASS M of OXYGEN IS 0.0320 kg/mol
of OXYGEN GAS molecules AT T = 300 K.

(a) WHAT IS THE AVERAGE SPEED V_{avg} of OXYGEN GAS molecules AT T = 300 K.

(b) WHAT IS THE ROOT MEAN SQUARE SPEED of V_{rms} AT 300 K.

(c) WHAT IS THE MOST PROBABLE SPEED V_p AT 300 K?

(a) $V_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.31\ J/_{mol \cdot K} \times 300}{3.1416 \times 0.0320}} = 445\ m/s$

(b) $V_{Rms} = \sqrt{\frac{3RT}{m}} = \sqrt{\frac{3 \times 8.31 \times 300}{0.0320}} = 483\ m/s$

(c) $V_p = \sqrt{\frac{2RT}{m}} = \sqrt{\frac{2 \times 8.31 \times 300}{0.0320}} = 395\ m/s$

GEN IS 0.0320 kg/mol

of OXYGEN GAS MOLECULES AT $T = 300\,K$.

RE SPEED of V_{rms} AT 300 K.

SPEED V_p AT 300K?

$$\frac{\ldots 31\ J/mol\,K \times 300}{16 \times 0.0320} = 445\ m/s$$

$$\frac{3 \times 8.31 \times 300}{0.0320} = 483\ m/s$$

$$\frac{\times 8.31 \times 300}{0.0320} = 395\ m/s$$

THE MOLAR SPECIFIC HEAT OF IDEAL GAS

INTERNAL ENERGY

$$E_{int} = \frac{3}{2} n R T$$