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Principles of Physics I
PHY1321
MIDTERM 1
Fall2015. Oct 17

NAME: ____________________________

Student # ____________________________

CLOSED BOOK TEST
TIME: 100minutes

Part 1. In the scantron sheet to answer all MC questions below. (Best 6 count towards 48% of your test mark)

1 A container with a one-liter capacity at 27°C is filled with helium to a pressure of 2 atm. (1 atm = $1.0 \times 10^5\ \mathrm{N/m^2}$.) How many moles of helium does it hold?

A 0.040 B 0.080 C 0.45 D 0.90 E 1.0

2 A bubble having a diameter of 1.00 cm is released from the bottom of a swimming pool where the depth is 5.00 m. What will the diameter of the bubble be when it reaches the surface? The temperature of the water at the surface is 20.0°C, whereas it is 15.0°C at the bottom. (The density of water is 1.00×10^3 kg/m^3.)

A 1.05 B 1.15 C 1.45 D 1.65 E 1.35

3 Five moles of an ideal gas expands isothermally at 100°C to five times its initial volume. Find the heat flow into the system.

A 2.5×10^4 B 1.1×10^4 J C 6.7×10^3 J D 2.9×10^3 J E 7.0×10^2 J

4 A heat pump with a coefficient of performance of 6 absorbs heat from the atmosphere at a rate of 35 kW. At what rate is it doing work?

A 5 kW B 7 kW C 41 kW D 3 kW E none of the above

5 Ratio of the N(V_{rms}) number of molecules that have speed equal to V_{rms}, to N(V_{mp}) the number of molecules having speed of V_{mp} is given by:

a) $\frac{N(v_{rms})}{N(v_{mp})} = \frac{2}{3}e^{-\frac{1}{2}}$ b) $\frac{N(v_{rms})}{N(v_{mp})} = \frac{2}{3}e^{\frac{1}{2}}$ c) $\frac{N(v_{rms})}{N(v_{mp})} = \frac{3}{2}e^{\frac{1}{2}}$ d) $\frac{N(v_{rms})}{N(v_{mp})} = \frac{2}{3}e^{-\frac{1}{2}}$

e) none of the above

6 In an adiabatic process 20 J of work are done on each mole of a gas. If the gas has 5 degrees of freedom, how much does its temperature change? Answer in terms of R.

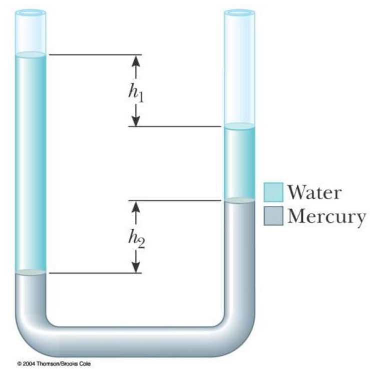
A) 20/R (K) B) 10/R (K) C) 20/7R (K) D) 8/R (K)
E) none of the above

7. In an isothermal process

a. the volume remains constant.
b. the internal energy is constant.
c. no heat is transferred between a system and its surroundings.
d. the pressure remains constant.
e. none of the above is correct statement about the isothermal process

PART 2 In examination booklets solve 4 out of 5 problems below. Each question has the same weight. (13p)
For full marks you need a neat diagram (when applicable) and all steps clearly demonstrated.

1 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. For h_2 = 1.00 cm, determine the value of h_1.



2. A 1.00-kg iron cube is taken from a forge at 900°C and dropped into 4.00 kg of water at 10.0°C. Assuming that no energy is lost by heat to the surroundings, determine

a) final temperature of the system. (7p)

b) the change of the volume of the iron cube as result of its temperature change . (3p)

c) the power radiated by the iron cube just before it was dropped into the water, and after the final temperature was established. (3p)

3 A 5.00-L sample of a diatomic ideal gas with specific heat ratio 9/7, confined to a cylinder, is carried through a closed cycle. The gas is initially at 2.00 atm and at 600 K. First, its pressure is tripled under constant volume. Then, it expands adiabatically to its original pressure. Finally, the gas is compressed isobarically to its original volume.

a) Draw a *PV* diagram of this cycle. (2p)
b) Determine the volume of the gas at the end of the adiabatic expansion. (2p)
c) Find the temperature of the gas at the start of the adiabatic expansion. (2p)
d) Find the temperature at the end of the cycle. (2p)
e) What was the net work done on the gas for this cycle? (3p)
f) Determine Cv and Cp for this gas (2p)

4 Given is one mole of N_2 gas at 27 C.

a) Use Maxwell Boltzmann Dsitribution to find the number of N_2 molecules having speeds between 420m/s and 422m/s (5p) (Molar mass of N_2 is 28g) (4p)

b) Using the Maxwell-Bolzmann Distribution show that that the most probable speed is given by:

$$v_{mp} = \sqrt{\frac{2kT}{m}} \qquad (4p)$$

c) What is the expected value of γ (gamma) for N_2 gas in this temperature?(2p)

d) Consider a a simple heat engine operating in a cycle corresponding to a rectangle on the pV diagram. How does its efficiency depend on the type of gas being used (its Cv)? (3p)
Show your calculations.

5 A Carnot heat engine uses a steam boiler at 100°C as the high-temperature reservoir. The low-temperature reservoir is the outside environment at 20.0°C. Energy is exhausted to the low-temperature reservoir at the rate of 15.4 W.

(a) Determine the useful power output of the heat engine. (8p)
(b) How much steam will it cause to condense in the high-temperature reservoir in 1.00 h? (5p)