Physics 5D Practice Midterm Exam Fall 2013

Closed book exam – only one 8.5x11" sheet of notes ok.

Note: Avogadro's number $N_A = 6.02 \times 10^{23}$ mol^{-1}, 1 atm = 1.0×10^5 Pa, Boltzmann's const $k = 1.38 \times 10^{-23}$ J/K, and the gas constant $R = 8.314$ J/mol·K = 1.99 cal/mol·K

Questions (5 points each) – Circle the Correct Answer:

1. A machinist needs to remove a tight fitting pin of material A from a hole in a block made of material B. The machinist heats both the pin and and the block to the same high temperature and removes the pin easily. What statement relates the coefficient of thermal expansion of material A to that of material B?

A) Material B has a greater coefficient of expansion than does material A.

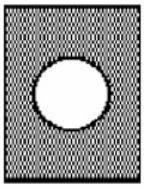
B) The situation is not possible, heating block B will shrink the hole in the material as the material expands with increasing temperature.

C) Material B has the same coefficient of expansion as does material A.

D) Material B has a negative coefficient of expansion and A has a positive coefficient of expansion.

E) Material A has a greater coefficient of expansion than does material B.

2. Consider a flat steel plate with a hole through its center as shown in the Figure. When the plate's temperature is increased, the hole will



A) expand only if it takes up more than half the plate's surface area.

B) contract if it takes up less than half the plate's surface area.

C) always contract.

D) always expand.

E) remain the same size.

3. What is wrong with the following statements? A fixed quantity of ideal gas at constant volume is warmed from a temperature of 20°C to 40°C. The pressure in the gas doubles during this process because the temperature doubles.

A) The appropriate temperature does not double during this process, so the pressure does not double either.

B) It is impossible to keep a fixed quantity of gas at constant volume during the temperature change specified in the problem.
C) The pressure changes to one half its initial value during this process.

D) The conclusion regarding the pressure cannot be reached because the mass of the ideal gas particles is unknown.

E) The pressure change will depend on whether the ideal gas particles are monatomic or polyatomic.

4. A thermometer is made such that the freezing point of water is defined to be 60.0°H and the boiling point of water at sea level is defined to be 520°H. What is the Celsius temperature at 240°H?

A) -13.8°C B) 34.6°C C) 31.0°C D) -7.8°C E) 39.1°C

5. A sample of an ideal gas is slowly compressed to one-half its original volume with no change in temperature. What happens to the average speed of the molecules in the sample?

A) It does not change.

B) It quadruples.

C) It doubles.

D) It halves.

E) None of the above

6. What would be the greatest effect of the finite size of molecules on the ideal gas law?

A) At low densities, the pressure would be less than that predicted by the ideal gas law.

B) At high densities, the pressure would be less than that predicted by the ideal

gas law.

C) At high densities, the pressure would be greater than that predicted by the ideal gas law.

D) At low densities, the pressure would be higher than that predicted by the ideal gas law.

E) There is no effect.

7. Phase changes occur

A) as the temperature decreases.

B) as the temperature increases.

C) as the temperature remains the same.

D) all of the above

E) none of the above

8. Which of the following best explains why sweating is important to humans in maintaining suitable body temperature?

A) Functioning of the sweat gland absorbs energy that otherwise would go into heating the body.

B) The high specific heat of water on the skin absorbs heat from the body.

C) Evaporation of moisture from the skin extracts heat from the body.

D) Moisture on the skin increases thermal conductivity, thereby allowing heat to flow out of the body more effectively.

E) None of the other choices is correct.

9. A liquid boils when its saturated vapor pressure

A) equals the equilibrium vapor pressure.

B) equals the external pressure.

C) exceeds the external pressure.

D) is between the equilibrium vapor pressure and the external pressure.

E) None of the other choices is correct.

10. A gas is quickly compressed in an isolated environment. During the event, the gas exchanged no heat with its surroundings. This process is

A) isothermal. B) isochoric. C) isobaric. D) adiabatic. E) idealistic.

11. A thermally isolated system is made up of a hot piece of aluminum and a cold piece of copper; the aluminum and the copper are in thermal contact. The specific heat capacity of aluminum is more than double that of copper. Which object experiences the greater magnitude gain or loss of heat during the time the system takes to reach thermal equilibrium?

A) the aluminum

B) the copper

C) neither; both experience the same size gain or loss of heat

D) it is impossible to tell without knowing the masses

E) it is impossible to tell without knowing the volumes

12. When the first law of thermodynamics, $Q = \Delta U + W$, is applied to an ideal gas that is taken through an isothermal process,

A) $\Delta U = 0$ B) $W = 0$ C) $Q = 0$ D) all of the above E) none of the above

13. When the first law of thermodynamics, $Q = \Delta U + W$, is applied to an ideal gas that is taken through an adiabatic process,

A) $\Delta U = 0$ B) $W = 0$ C) $Q = 0$ D) all of the above E) none of the above

14. When the first law of thermodynamics, $Q = \Delta U + W$, is applied to an ideal gas that is taken through an isobaric process,

A) $\Delta U = 0$ B) $W = 0$ C) $Q = 0$ D) all of the above E) none of the above

15. When the first law of thermodynamics, $Q = \Delta U + W$, is applied to an ideal gas that is taken through an isochoric ($\Delta V = 0$) process,

A) $\Delta U = 0$ B) $W = 0$ C) $Q = 0$ D) all of the above E) none of the above

16. During which type of process applied to an ideal gas is there no heat added to the gas?

A) isobaric B) isochoric C) isothermal D) adiabatic E) A and C

17. When a gas expands adiabatically,

A) the internal energy of the gas decreases.

B) the internal energy of the gas increases.

C) there is no work done by the gas.

D) work is done on the gas.

E) heat flows out of the system.

18. If 40 kcal of heat is added to 2.0 kg of water, what is the resulting temperature change?

A) 80C° B) 60C° C) 40C° D) 20C° E) 0.05C°

19. How much heat is required to change 456 g of ice at -25.0°C into water at 25.0°C? The specific heat of ice is 2090 J/(kg·K), the latent heat of fusion of water is 335 kJ/kg, and the latent heat of vaporization of water is 2260 kJ/kg.

A) 224 kJ B) 153 kJ C) 112 kJ D) 71.5 kJ E) 72.5 kJ

20. During an isothermal process, 5.0 J of heat is removed from an ideal gas. What is the change in internal energy?

A) zero B) 2.5 J C) 5.0 J D) 7.5 J E) 10 J

Problems (10 points each):

21. The element nitrogen has atomic weight 14. Two liters of nitrogen gas are at 0°C and 1 atm. Treating the nitrogen as an ideal gas,

(a) Determine the number of moles.

(b) Determine the number of molecules.

(c) Determine the mass of the gas.

22. The van der Waals equation of state is $(P+a/v^2)(v-b) = RT$ where $v = V/n$, V is the volume and n is the number of moles. For chlorine gas, the van der Waals constants are: a = 0.658 J·m^3/mol^2, and b = 5.62 x 10^{-5} m^3/mol. A 3.0-L tank contains 10.0 moles of chlorine gas at a temperature of 625 K. What is the pressure in the container?

A) 14.0 MPa B) 13.5 MPa C) 17.3 MPa D) 11.0 MPa E) 18.2 MPa

23. The density of atoms, mostly hydrogen, in a region of interstellar space is about one per cubic centimeter. What is the mean free path of the hydrogen atoms, assuming an atomic diameter of 10^{-10} m.

24. (a) How much energy is required to bring a 1.0 liter pot of water at 20°C to 100°C?

(b) For how long could this amount of energy run a 100 W light bulb?

(c) How much energy is required to completely evaporate a 1.0 liter pot of water at 100°C?

25. An iron meteorite melts when it enters the earth's atmosphere and slows down. If its initial temperature was -105°C outside the atmosphere, calculate the minimum velocity that it must have had when it entered the atmosphere. (The specific heat of iron is 450 J/kg·K, T_{melt} = 1808°C, and L_{fusion} = 2.89 x10^5 J/kg.)