Print your name: _____

Physics 5D PRACTICE FINAL EXAM Fall 2013

Real Exam is Wednesday December 11 – Thimann Lecture 3 – 4:00-7:00 pm
Closed book exam – two 8.5x11" sheets 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 constant $k = 1.38 \times 10^{-23}$ J/K, the gas constant $R = 8.314$ J/mol·K = 1.99 cal/mol·K, and the Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ W/m^2 \cdot K^4$. For water, the latent heats are $L_{fusion} = 3.33 \times 10^5$ J/kg and $L_{vaporization} = 2.26 \times 10^6$ J/kg.

Questions

1. (5 points) State the anomalous thermal expansion property of water and its significance.

2. (5 points) State the 1st Law of Thermodynamics in words and an equation.

3. (10 points) Draw a Carnot cycle on both a P-V and S-T diagram, label each stage of the cycle with the type of process, and show Q_H entering and Q_L exiting.

4. (5 points) Give the Clausius statement of the 2nd Law of Thermodynamics

5. (5 points) Give the Kelvin-Planck version of the 2nd Law of Thermodynamics.

6. (5 points) State the entropy version of the 2nd Law of Thermodynamics for an isolated system.

Questions (5 points each) - Circle the Correct Answer

7. A person tries to heat up her bath water by adding 5.0 L of water at 80°C to 60 L of water at 30°C. What is the final temperature of the water?

A) 34°C B) 36°C C) 38°C D) 40°C E) 65°C

8. The triple point of water occurs at a unique temperature and pressure.

True False

9. Express -40°F in °C.

A) −34°C B) −36°C C) −38°C D) −40°C E) −65°C

10. The coefficient of linear expansion of steel is $12 \times 10^{-6}\,K^{-1}$. What is the change in length of a 25 m steel bridge span when it undergoes a temperature change of 40 K?

A) 1.2 cm B) 1.4 cm C) 1.6 cm D) 1.8 cm E) 2.0 cm

11. A constant volume closed container of gas is at 1 atm pressure at 20°C. What is its pressure if the temperature of the gas is increased to 60°C?

A) 1.33 atm B) 9.00 atm C) 0.880 atm D) 3.00 atm E) 1.14 atm

12. How many water molecules are there in 36 g of water? Express your answer as a multiple of Avogadro's number N_A.

A) 36 N_A B) 2 N_A C) 6 N_A D) 18 N_A E) none of these

13. 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

14. What would be the greatest effect of the finite size of molecules on the pressure P compared to the ideal gas law?

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

B) At high densities, P would be less than that predicted by the ideal gas law.

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

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

E) There is no effect.

15. The point in the phase diagram where the vapor pressure curve ends is called the

A) critical point. B) triple point. C) melting point. D) boiling point.

16. When a liquid evaporates

A) its temperature increases. B) its temperature decreases.

C) heat energy leaves the substance. D) heat energy enters the substance.

17. Convective heat transfer can only occur if fluids mediate the energy transfer.

True False

18. It is a well-known fact that water has a higher specific heat capacity than iron. Now, consider equal masses of water and iron that are initially in thermal equilibrium. The same amount of heat, 30 calories, is added to each. Which statement is true?

A) They remain in thermal equilibrium.

B) They are no longer in thermal equilibrium; the iron is warmer.

C) They are no longer in thermal equilibrium; the water is warmer.

D) It is impossible to say without knowing the exact mass involved.

E) It is impossible to say without knowing the exact specific heat capacities.

19. A chunk of ice (T = -20°C) is added to a thermally insulated container of cold water (T = 0°C). What happens in the container?

A) The ice melts until thermal equilibrium is established.

B) The water cools down until thermal equilibrium is established.

C) Some of the water freezes and the chunk of ice gets larger.

D) none of the above.

20. During which type of process applied to a gas is no work done by the gas?

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

21. Consider two cylinders of gas identical in all respects except that one contains O_2 and the other He. Both hold the same volume of gas at STP and are closed by

a movable piston at one end. Both gases are now compressed adiabatically to one-third their original volume. Which gas will show the greater pressure increase?

A) The O_2 B) The He C) Neither; both will show the same increase.

D) It's impossible to tell from the information given.

22. A solid concrete wall 4.0 m by 2.4 m and 30 cm thick, with a thermal conductivity of 1.3 W/(m·K), separates a basement at 18°C from the ground outside at 6°C. How much heat flows through the wall in one hour?

A) 1.8 MJ B) 1.8 kJ C) 500 J D) 5.0 MJ E) 5.0 kJ

23. How much power does a sphere with a radius of 10 cm radiate if is has an emissivity e = 1.0 and is kept at a temperature of 400 K? The Stefan-Boltzmann constant is 5.67×10^{-8} W/(m^2·K^4).

A) 60 W B) 70 W C) 180 W D) 210 W E) 360 W

24. The efficiency of a heat engine is defined as the ratio of

A) the heat input at the high temperature to the heat output at the low temperature.

B) the heat output at the low temperature to the heat input at the high temperature.

C) the work it does to the heat input at the high temperature.

D) the work it does to the heat output at the low temperature.

E) the work it does to the difference between the heat input from the heat output.

25. Which of the following is an example of a reversible process?

A) An ice cube at 0°C melts while in a water bath at 0°C.

B) A hand pump is rapidly compressed and the pressure and temperature in the pump rise. The pump is held in position as the temperature drops to the ambient temperature.

C) A stick of dynamite explodes.

D) A high pressure air tank at room temperature has its valve opened and the gas in the tank rushes out until the pressure in the tank is equal to atmospheric pressure.

E) A car engine burns fuel to produce motion of the car and exhausts the 140°C waste products of the combustion into the 20°C atmosphere.

Problems (10 points each):

26. (a) Find the total power radiated by the sun, assuming that it is a perfect emitter at $T = 5500$ K. The sun's radius is 7.0×10^5 km. (b) From this, determine the power per square meter arriving at the earth, 150×10^6 km away.

27. 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 velocity that it must have had when it entered the atmosphere. (The specific heat of iron is 450 J/kg·K, $T_{\text{melt}} = 1808$°C, and $L_{\text{fusion}} = 2.89 \times 10^5$ J/kg.)

28. The density of atoms, mostly hydrogen, in 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.

29. 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. The constant b represents the amount of unavailable volume occupied by the molecules themselves. For oxygen, b is about 3.2×10^{-5} m^3/mol. Estimate the diameter of an oxygen molecule, assuming for simplicity that it is spherical.

30. An aluminum can with negligible heat capacity is filled with 450 g of water at 0°C and then is brought into thermal contact with an identical can filled with 450 g of water at 50°C. Find the change in entropy if no heat is exchanged with the surroundings.