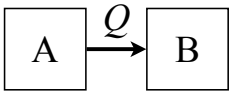
Physics 3410 Name:_____

April 13, 2016 Exam 2 21 questions, 89 points

1. Heat flows from system A to system B.



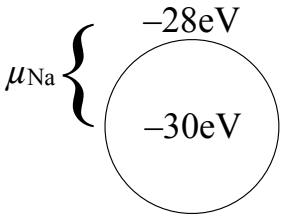
[3] (a) _____ During the heat flow, the entropy of A

A) increases **B)** stays the same **C)** decreases

[3] (b) If U_A and U_B are the energies of the two systems, what is $\frac{dU_A}{dU_B}$?

[3] 2. _____ The chemical potential of sodium inside a cell is $\mu_{\text{Na}} = -30\,\text{eV}$; outside the cell, $\mu_{\text{Na}} = -28\,\text{eV}$. For the two sides to reach equilibrium, sodium would have to flow

A) into the cell **B)** out of the cell



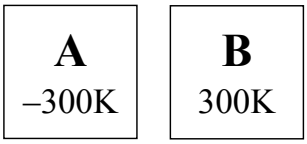
[3] 3. _____ System A has a temperature of $T = -300\,\text{K}$, and system B has a temperature of $T = 300\,\text{K}$. If the systems are placed in contact,

A) heat will flow from A to B

B) heat will flow from B to A

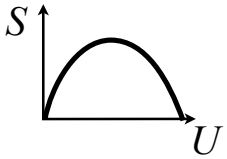
C) they will undergo matter-antimatter annihilation

D) none of the above



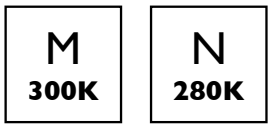
[2] 4. _____ A paramagnet in a magnetic field has an entropy $S(U)$ as shown. It has negative temperature when its energy is

A) low **B)** high **C)** never



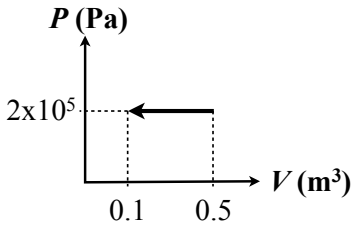
$S(U)$ for a paramagnet

3 5. _____ A miserly system at $T = 300\,\mathrm{K}$ is placed in contact with a normal system at $T = 280\,\mathrm{K}$. What happens initially?



A) Both systems get hotter **B)** Both systems get colder
C) M gets colder, N gets hotter **D)** None of these.

6. The figure shows a process of an ideal gas with $f = 3$, on a PV diagram. The internal energy decreases by $-120\,\mathrm{kJ}$ during the process.



3 (a) _____ How much work is done during this process? (Positive means work flows into the gas.)

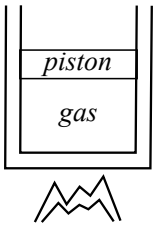
A) $+10\,\mathrm{kJ}$ **B)** $+20\,\mathrm{kJ}$ **C)** $+80\,\mathrm{kJ}$
D) $-10\,\mathrm{kJ}$ **E)** $-20\,\mathrm{kJ}$ **F)** $-80\,\mathrm{kJ}$

3 (b) _____ *How much* heat Q flows into or out of the gas?

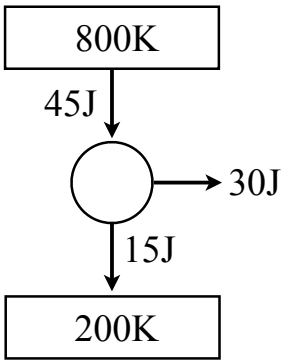
A) $0\,\mathrm{kJ}$
B) $-80\,\mathrm{kJ}$ **C)** $-120\,\mathrm{kJ}$ **D)** $-200\,\mathrm{kJ}$
E) $+80\,\mathrm{kJ}$ **F)** $+120\,\mathrm{kJ}$ **G)** $+200\,\mathrm{kJ}$

3 7. _____ Which is faster?
A) an adiabatic process **B)** an isothermal process

3 8. _____ Suppose gas is in a container sealed by an ideal piston that is free to move. The gas is heated, and the gas expands. This is an ... expansion.
A) adiabatic **B)** isobaric **C)** isothermal



9. This figure shows a heat engine operating between 200 K and 800 K.

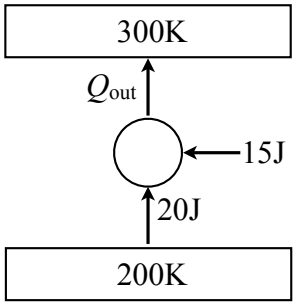


3 (a) _____ What is this engine's efficiency?
A) 25% **B)** 33% **C)** 67% **D)** 75%

3 (b) How much work would this engine produce for the same amount of heat $Q_{in} = 45\,\text{J}$, if it were a Carnot engine?

3 10. _____ Nitrogen gas ($f = 5$) at standard pressure ($P = 1\,\text{atm}$) expands adiabatically to twice its volume. What is the pressure of the gas after the expansion?
A) 0.38 atm **B)** 0.5 atm **C)** 1 atm **D)** 2 atm **E)** 2.6 atm

11. This figure shows a refrigerator.



3 (a) _____ How much heat Q_{out} flows into the hot reservoir?
A) 5 J **B)** 15 J
C) 20 J **D)** 35 J

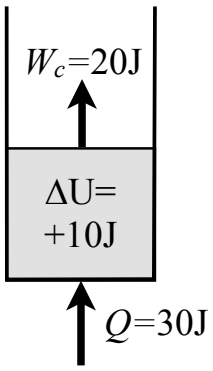
3 (b) _____ What is its Coefficient of Performance?
A) 0.33 **B)** 0.43 **C)** 0.75
D) 1.33 **E)** 2 **F)** 2.33

3 12. _____ Which of these is an intensive quantity?
A) internal energy **B)** pressure **C)** volume

3 13. _____ A car has two identical hubcaps: one is shiny and new, the other is rusty. Which has the larger Gibbs free energy?
A) the shiny one **B)** the rusty one

3 14. _____ How does the van der Waals model differ from the ideal gas model?
A) it models a phase transition
B) it takes into account the minimum volume of atoms
C) it explains the critical point
D) all of the above

15. During a chemical process at constant temperature and pressure, 30 J of heat flows into the system, the internal energy increases by $\Delta U = +10\,\text{J}$, and 20 J of compression work flows outward to move the air out of the way.



2 (a) _____ What is the change ΔH in the enthalpy?
A) $-20\,\text{J}$ **B)** $-10\,\text{J}$ **C)** $0\,\text{J}$
D) $+10\,\text{J}$ **E)** $+20\,\text{J}$ **F)** $+30\,\text{J}$

2 (b) _____ What is the change ΔG in the Gibbs free energy?
A) $-20\,\text{J}$ **B)** $-10\,\text{J}$ **C)** $0\,\text{J}$
D) $+10\,\text{J}$ **E)** $+20\,\text{J}$ **F)** $+30\,\text{J}$

16. We can write the thermodynamic identity of a rubber band as

$$dU = T\,dS + F\,dL$$

where L is the length of the rubber band, and F is the tension in the rubber band.

3 (a) What are the natural variables of U *in this case*?

3 (b) What is $\left(\frac{\partial S}{\partial L}\right)_U$?

3 (c) _____ Which of these is a pair of conjugate variables?

A) T & U **B)** S & L **C)** F & L **D)** U & S

3 17. What is $\left(\frac{\partial H}{\partial S}\right)_{P,N}$?

18. In the following equation, fill in the blanks.

$$\left(\frac{\partial \boxed{\text{(a)}}}{\partial V}\right)_{T,N} = \boxed{\text{(c)}} \left(\frac{\partial P}{\partial N}\right)_{V,\boxed{\text{(b)}}}$$

2 (a) _____

F) F μ) μ **N)** N **P)** P **S)** S **T)** T **V)** V

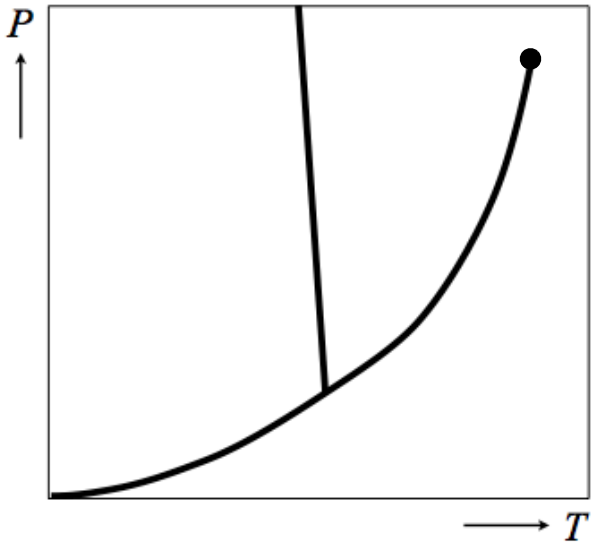
2 (b) _____

F) F μ) μ **N)** N **P)** P **S)** S **T)** T **V)** V

2 (c) _____

+) + −) −

5 19. This figure is the phase diagram of water. Label the following regions and points on the diagram. (You can use the letter or the word as you like.)
S) solid **L)** liquid **G)** gas **T)** triple point **C)** critical point



20. Consider a new material called *bowlingrene*. At standard atmospheric pressure, the Gibbs free energy (in joules per mole) of the solid and liquid phases of bowlingrene, as functions of temperature, are

$$\text{solid: } G_s(T) = -8000 - 30T \qquad \text{liquid: } G_l(T) = +8000 - 80T$$

The entropy of each phase is independent of temperature, and the pressure is held constant.

3 (a) Find the entropy (per mole) of solid bowlingrene.

3 (b) _____ At 300 K, bowlingrene is

A) solid **B)** liquid

3 (c) Find the melting/freezing temperature of bowlingrene. *(Note: your answer shouldn't contradict your answer to part (b).)*

3 XC 21. **Extra Credit:** The figure shows the boundary between the solid and liquid phases of a material. At $P = 1\,\text{atm}$, the solid phase has a density of $\rho = 900\,\text{kg/m}^3$, the liquid phase has a density of $\rho = 800\,\text{kg/m}^3$, and the latent heat of fusion is $L = 4000\,\text{J}$. Find the slope of the boundary (with the correct units).