

Name: _____

Physics 3410

Sample Exam 1
March 2, 2015

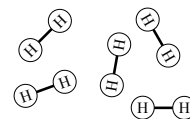
- Turn off your cell phone NOW, if you have one, and put it away. Avoid the appearance of impropriety.
- This is a closed-book exam. You may use two sheets of notes (two-sided) and your own calculator (not a cell phone or other wireless device, and not shared with another student).
- This test contains 17 questions and 69 points. The point value of each question may be found in a little box, like so: 3.
- If any question seems ambiguous, ask me about it. Raise your hand (and maybe clear your throat if I'm not looking) and I will come to you; please remain seated.
- Partial credit is available *everywhere*; when in doubt, explain your reasoning. If you need more room to write, use the back of a sheet, but tell me that you are continuing on the back.
Show your work.
- In the event that I have to make a correction or clarification to the exam, I will announce it and write it on the board; if I do so, you are responsible for taking these corrections into account.
- Look out for *emphasized* and **bolded** words; they are usually important.
- Make sure that all answers that need units, get units.
- Please use the little blank (_____) for your answers, where provided. If there is no blank, please box or circle your final answer.
- When you're done, place the exam in the appropriate pile, and leave quietly; please do not stand outside the doors talking about the exam.

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

Good luck!

- 3 1. _____ Which of the following is an extensive variable?
A) pressure **B)** temperature **C)** volume
- 3 2. _____ True or false: If an object cools down, then heat must have flowed out of it.
- 3 3. _____ Which kind of heat can travel through vacuum?
A) conduction **B)** convection **C)** radiation **D)** none of these **E)** all of these

4. Hydrogen gas, containing 2×10^{24} molecules of H_2 , has temperature $T = 800 \text{ K}$ and is at pressure $P = 3 \times 10^4 \text{ Pa}$. *All* of its degrees of freedom are active.



- 3 (a) What volume does the gas occupy?

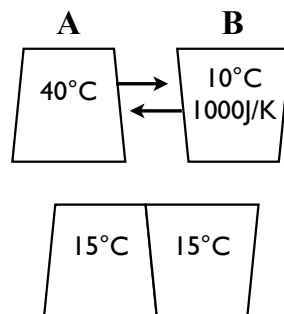
- 3 (b) What is the internal energy U of the gas?

- 3 5. _____ Block A has heat capacity $C = 400 \text{ J/K}$, and block B has $C = 300 \text{ J/K}$. Both blocks are removed from a 5°C refrigerator and placed in a 20°C room until they reach room temperature. Which block absorbs more heat from the room?
A) Block A **B)** Block B
C) Both blocks absorb the same amount of heat

A
 $C=400 \text{ J/K}$

B
 $C=300 \text{ J/K}$

6. Block A starts at 40°C , and block B starts at 10°C . They are placed in contact with each other, and heat flows between them until the temperature of both is 15°C . (No heat flows into or out of the environment.)



- 3 (a) _____ Which block has the larger heat capacity?

A) Block A **B)** Block B
C) Both have the same heat capacity

- 1 (b) _____ In which direction does heat flow?

A) into A **B)** into B

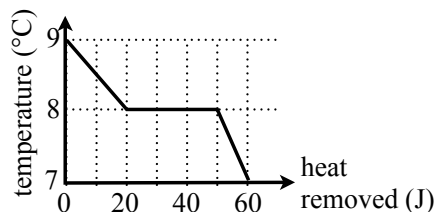
- 3 (c) _____ If the heat capacity of block B is $C = 1 \text{ kJ/K}$, how much heat flows between the blocks?

A) 1 kJ **B)** 5 kJ **C)** 10 kJ
D) 15 kJ **E)** 25 kJ **F)** 30 kJ

- 2 7. _____ When water vapor condenses to a liquid

A) it absorbs energy from the surroundings **B)** its temperature drops sharply
C) it transfers heat to the surroundings **D)** its temperature rises slightly

- 2 8. A certain liquid starts at 9°C , and 60 J of heat is slowly removed from it, as shown. Once it reaches 7°C , it has become a solid. What is the latent heat of freezing of this liquid, in Joules?



9. A gas shrinks and cools.

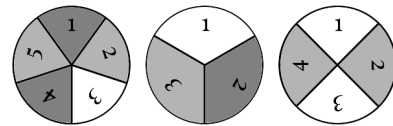
2 (a) _____ Work flows...
A) into the gas **B)** out of the gas **C)** neither

2 (b) _____ The internal energy of the gas...
A) increases **B)** decreases **C)** stays the same

2 (c) _____ Heat flows...
A) into the gas **B)** out of the gas **C)** neither
D) can't tell without more information

10. The figure shows three spinners on a combination lock.

3 (a) How many possible combinations could the lock have?

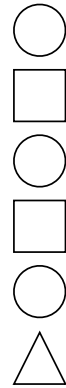


3 (b) Describe, in words, a macrostate of this lock with $\Omega > 1$.

3 11. _____ Calculate $\binom{8}{5}$.
A) 1.6 **B)** 56 **C)** 112 **D)** 336 **E)** 792 **F)** 6720

12. Consider three circles, two squares, and a triangle in a pile, as shown.

3 (a) How many different sequences can one make from these six shapes?



3 (b) If the shapes are being shuffled randomly, what is the probability that a circle is at the top?

13. Consider a paramagnet with 10 dipoles. Let $U = 0, 1, 2, \dots, 10$ be our “normalized energy”.

3 (a) What is the multiplicity Ω of the paramagnet, if its energy is $U = 1$?

3 (b) _____ Which energy macrostate has the greater multiplicity?
A) $U = 5$ **B)** $U = 9$

3 14. What is the multiplicity of an Einstein solid with $N = 2$ oscillators and $q = 3$ quanta of energy?



- 3 15. In the low-temperature limit $N \gg q \gg 1$, the multiplicity of an Einstein solid is approximately $\Omega = (eN/q)^q$. Find the approximate *entropy* of an Einstein solid when $N = 3 \times 10^6$ and $q = 10^6$ (assuming both qualify as big numbers).

- 4 16. The figure shows the multiplicity of an ideal gas with N particles, volume V , and internal energy U . In each of the blanks, indicate whether the corresponding factor is due to
 A) The position microstates
 B) The momentum microstates
 C) The indistinguishability of the particles

$$\Omega = \frac{1}{\boxed{N!}} \frac{(2\pi m)^{3N/2}}{h^{3N} \boxed{\left(\frac{3N}{2}\right)!}} \boxed{V^N} \boxed{U^{3N/2}}$$

- 3 17. _____ When gas leaks out of a hot-air balloon, the entropy of the gas
 A) increases B) stays the same C) decreases