Physics 161 Fall 2011
Midterm Exam 1 – Thermodynamics
Please sit in odd # seats. Use a 10-answer scantron.
LAST NAME COMES FIRST

Closed Book, Notes, Cellphones OFF
Calculators OK

$pV = nRT$

pV^{γ} = constant (Q=0)

$Q = nC_v\Delta T$ (constant V)

$\gamma = C_p/C_v$

$C_p = C_v + R$

$C_v = \frac{3}{2}R$ (monatomic ideal gas)

$\Delta U = Q - W$

$R = 8.3$ J/molK

$$dS = \frac{dQ}{T}$$

$$W = \int p\,dV$$

$$e = \frac{W}{Q_H}$$

$$e_c = 1 - \frac{T_C}{T_H}$$

For H_2O:

$L_f = 334$ J/g

$L_v = 2256$ J/g

$c = 4.2$ J/gK (water)

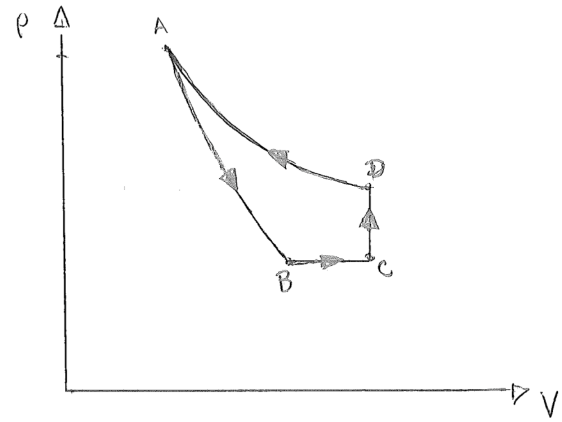
$= 2.1$ J/gK (ice)

$T_f = 273$K

Math:

$$\int \frac{dx}{x} = \ln(x)$$

A thermodynamic cycle is shown, consisting only of paths that are isobaric, isochoric, isothermal, or possibly adiabatic.



1. Which side is adiabatic?
2. Which side is isochoric?
3. Which side is isobaric?
4. Which side is isothermal?

Choose:

A) AB	B) BC	C) CD
D) DA	E) > 1 side	F) No side

5. The cycle shown is
A) an engine   B) a refrigerator C) cannot determine without more information

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6. In an isothermal expansion of an ideal gas:
A) Heat is removed; entropy of the gas decreases
B) No heat is exchanged, entropy of the gas decreases
C) Heat is added; entropy of the gas decreases
D) Heat is removed; the entropy of the gas is unchanged
E) No heat is exchanged; the entropy of the gas is unchanged
F) Heat is added; the entropy of the gas is unchanged
G) Heat is removed; the entropy of the gas increases
H) No heat is exchanged; the entropy of the gas increases
I) Heat is added; the entropy of the gas increases
J) None of these is always correct, as answers differ for monatomic & polyatomic gases.

7. In an isothermal expansion of an ideal gas:
A) All added heat is converted into work
B) Not all added heat is converted into work, as the 2^{nd} law of thermodynamics prohibits 100% efficiency
C) The fraction of heat converted into work depends on whether the gas is monatomic or polyatomic

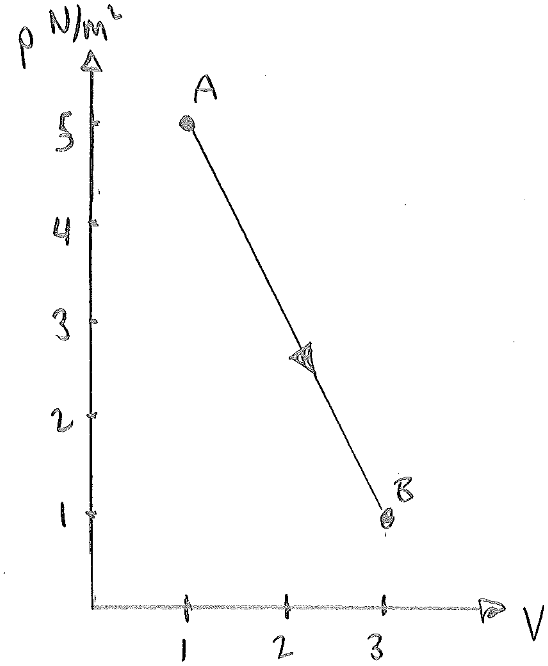
8. Repeat Q6 for the free expansion of an ideal gas.

9. A monatomic ideal gas undergoes an adiabatic compression that reduces its volume by a factor of three. By what factor does this increase the pressure? (Choose the nearest integer 0-9)

10. Which is true?
A) No reversible engine can exceed Carnot efficiency, but an irreversible one can
B) No irreversible engine can exceed Carnot efficiency, but a reversible one can
C) No engine can exceed Carnot efficiency

11. Which is true?
A) All real processes are reversible, because the laws of mechanics depend only on second derivatives with respect to time
B) No real processes are reversible, because thermodynamic reversibility requires heat flow with infinitessimal temperature differences
C) Some real processes are reversible, like heating, but phase changes are “irreversible”

A straight-line process is done on a monatomic ideal gas, as shown.



12. For the straight-line process shown, is work done ON the gas or BY the gas?
A) On the gas
B) By the gas
C) No work is done

13. What is the magnitude of the work done, to the nearest Joule?

14. If the temperature of the gas at point A is 500 K, what is the temperature of the gas at point B (to the nearest 100K?)

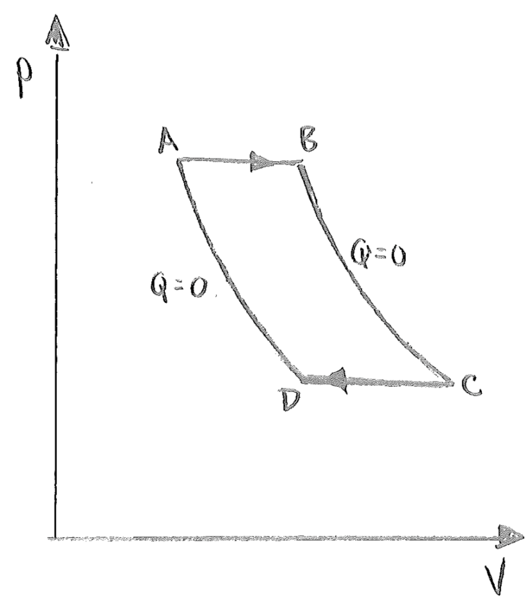
A) 0K	B) 100K	C) 200K	D) 300K
F) 500K	G) 600K	H) 700K	I) 800K

15. Is heat added to the gas, or removed from the gas?
A) added
B) removed
C) no heat is added or removed.

16. What is the magnitude of the heat transferred, to the nearest Joule?

Consider the thermodynamic cycle shown. The medium is an ideal gas.

17. This cycle is
A) a Carnot cycle
B) not a Carnot cycle



18. Where is the highest temperature reached? Choose A,B,C,D, or
E) somewhere along side AB
F) somewhere along side BC
G) somewhere along side CD
H) somewhere along side DA

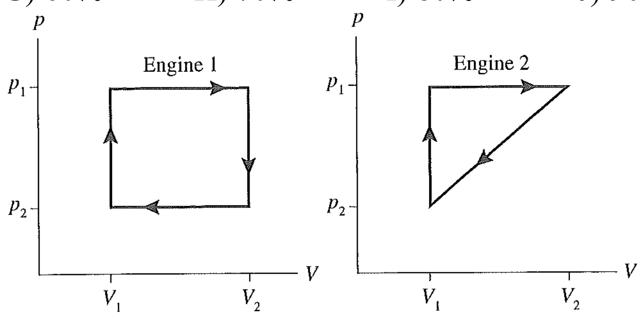
19. During this cycle, 7 J of (net) work is done by the gas. Along side CD, 16.3 J of heat is transferred. What is the thermodynamic efficiency of this device, to the nearest 10%

A) 0	B) 10%	C) 20%	
D) 30%	E) 40%	F) 50%	
G) 60%	H) 70%	I) 80%	J) 90%

20. The thermodynamic efficiency of the device on the left is 40%. What is the efficiency of the device on the right, to the nearest 10% (hint: think about where Q is added to the gas & net work done)?

A) 0 B) 10% C) 20% D) 30% E) 40% F) 50%

G) 60% H) 70% I) 80% J) 90%



21. Which is true about the entropy of the gas and the entropy of the hot & cold reservoirs in an **irreversible** engine taken ONCE around a cycle?

A) Both gas entropy and reservoir entropy increase
B) Gas entropy is unchanged, but reservoir entropy increases
C) Gas entropy increases, but reservoir entropy is unchanged
D) Both gas entropy and reservoir entropy are unchanged
E) Gas entropy decreases, but reservoir entropy increases more
F) Gas entropy is unchanged; reservoir entropy decreases

22. 10 g of ice at 0°C is mixed with 100 g water at 10°C in a thermos. What is the composition at thermal equilibrium?

A) All ice
B) A mix of ice & water
C) All water
D) Ice, water, and steam

23. What is the temperature, to the nearest °C?

24. 40 g of water is cooled from 20°C to 10°C. What is the magnitude of the entropy change, to the nearest J/K?

25. The entropy

A) Increases B) Decreases C) Is unchanged

26. Following in Albert Einstein's footsteps, after an unexceptional college career, you take a job at the patent office. Joe Boltzmann submits a patent for a new solar thermal engine, that heats water at 20°C to 100°C and then boils it, using the 100°C steam to do useful work (making electricity) then allowing it to condense and cool back to 20°C. Boltzmann's patent application claims a thermodynamic efficiency of 40%. Should you allow the patent?

A) yes – the efficiency does not exceed Carnot efficiency
B) yes – the change of phase from water to steam allows this engine to exceed Carnot efficiency
C) no – Joe is claiming an efficiency greater than Carnot.
D) no – Joe's engine must violate the first law of thermodynamics (conservation of energy)