Midterm 2 study Pro Tips

For midterm 2, you are going to need to master the following things:

1) Problems involving ideal gas processes

2) Radiation problems

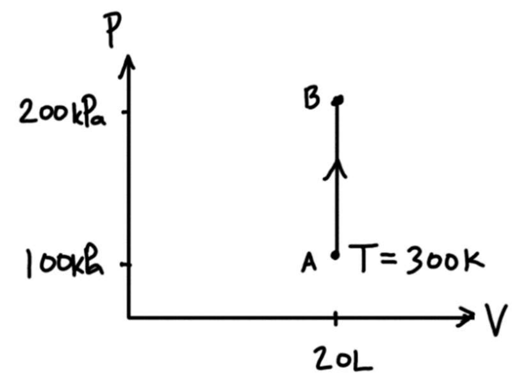
3) Multiple choice conceptual questions, including entropy

Use the guide below to study efficiently.

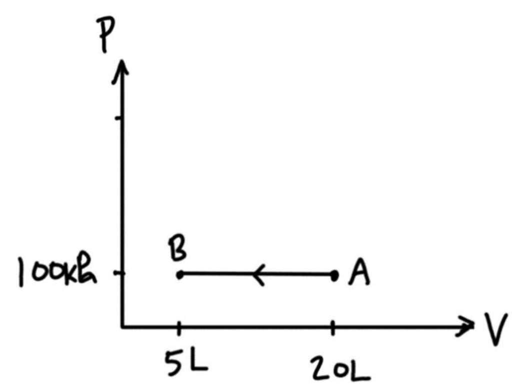
1) Problems involving ideal gas processes: do 1-13 below and then practice problems

For adiabatic, isothermal, constant volume, and constant pressure processes, you need to be able to calculate final T, P, or V, and Q, W, and ΔU for the process. You should be completely comfortable doing each of the following (see the flow chart on the next page if you're stuck):

1) For the process on the right, what are n, T_B, Q, W, and ΔU, assuming we have a monatomic ideal gas?

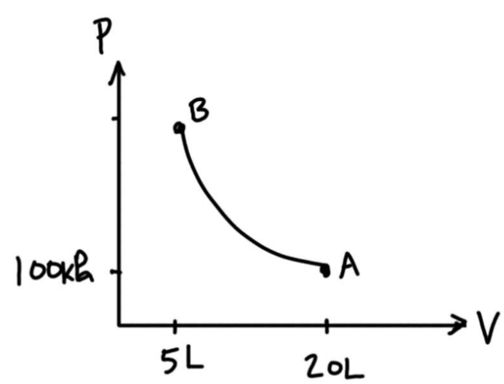


2) The process on the right involves 2 moles of an ideal gas with $\gamma = 1.4$. What are T_A, T_B, Q, W, and ΔU?

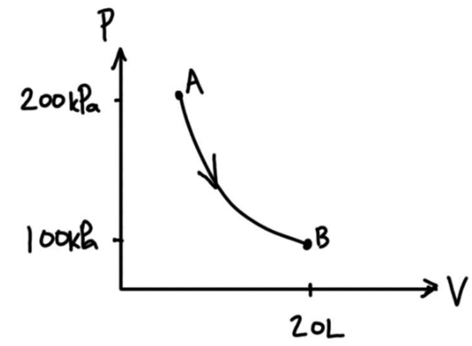


3) The process on the right is isothermal, at temperature $T_A = 300K$, with $C_V = 3R$.

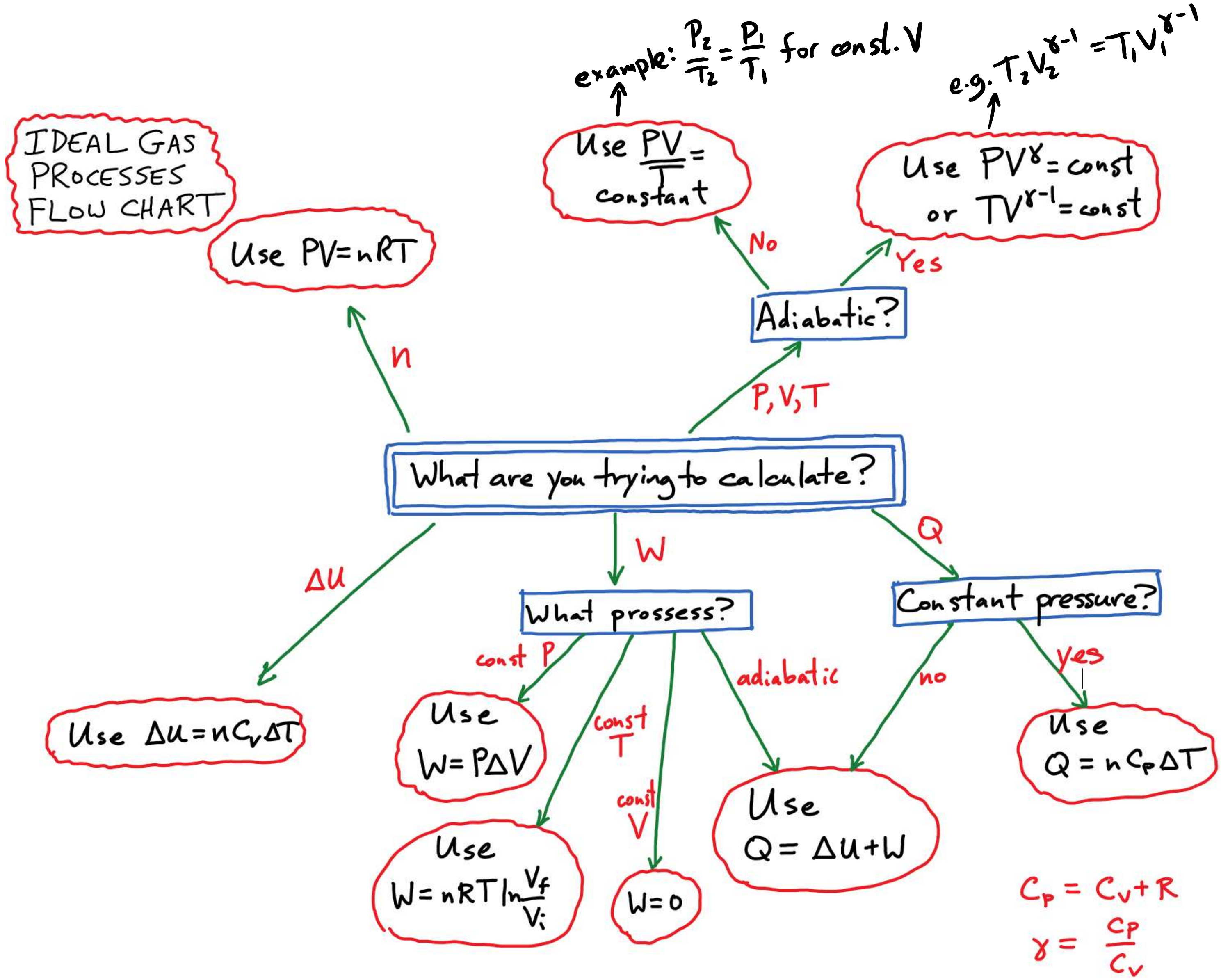
What are T_B, P_B, Q, W, and ΔU?



4) The process on the right is adiabatic, with 1 mole of gas for which $C_P = 7R/2$. What are T_B, T_A, V_A, Q, W, and ΔU?



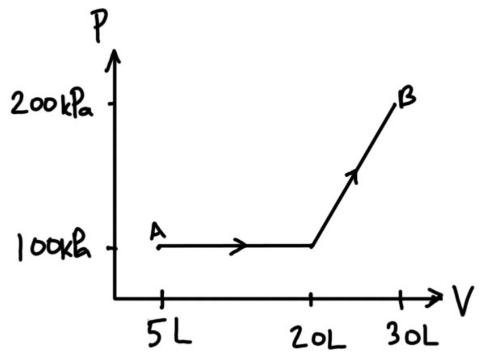
Try the questions above and note down any quantities that you didn't immediately know how to calculate. Go back later and try those parts again. The flow chart below summarizes the methods that you can use for all cases.



Apart from those basic processes, there are a couple of other things that sometimes come up:

Calculating work from a graph for some other type of process:

5) What is the work done by the gas in the process shown?



Processes that involve external forces:

6a) One mole of gas is in a cylinder with cross sectional area $0.1m^2$ the cylinder has a freely moving piston on top, upon which sits a 500kg mass. What is the pressure of gas in the cylinder (assume the outside air pressure is atmospheric pressure)?

6b) We now add another 500kg, so that the gas *rapidly* compresses. If the gas compresses by 1cm when the downward velocity of the blocks is zero, what is the change in internal energy of the gas?

For full cycles, you will need to be able to calculate efficiency. Here, it's useful to know that $e = W_{net}/Q_{in}$, where Q_{in} represents all the positive contributions to Q. It's also useful to know that $\Delta U = 0$ for a full cycle, so $W_{net} = Q_{in} + Q_{out}$. Finally, you'll need to know that the power of an engine is the net work done per time.

7) For questions 1-4, try to figure out whether Q is positive or negative (without calculating Q explicitly)

8) A certain engine takes in 3000J of heat each cycle and expels 1000J of heat. What is its efficiency?

9) A certain engine with e=0.6 has 6 cylinders. The engine runs at 3000RPM, and each cylinder goes through a cycle for each 2 revolutions. If each cylinder does

1000J of work per cycle, what is the engine's power? How much gasoline (35MJ/L) does it burn per hour?

Conceptual things:

You should be able to identify the type of process from a description, and also sketch each process on a graph.

10) Which type of process is each of the following?

a) A gas in a sealed cubical container with sides of length 0.5m is heated.

b) A gas is heated in a container has a freely moving piston on top with a weight of 200kg.

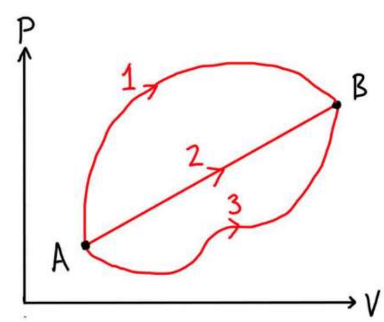
c) A gas is very slowly compressed while in contact with a water bath at 300K

d) A gas is very rapidly compressed by pushing on a piston.

e) a gas in an insulated container is expanded slowly by pulling on a piston.

11) What is the easy way to tell whether work done by a gas is positive, negative or zero for a process?

12) Which of the processes on the right has the largest W? Which has the largest Q? Which has the largest ΔU?



13) A gas is confined to half a box. There is no gas in the other half. Now the partition is removed so that the gas fills the box. In this process does the temperature increase, decrease, or stay the same assuming an ideal gas?

Additional practice problems:

Old midterm questions on basic ideal gas processes: MT2 2017 #1, MT1 2015 #3, MT1 2014 #3, MT2 2013 #2, MT2 2012 #2, MT2 2011 #3, MT1 2010 #3

Gas process problems that include sketching a PV diagram: MT2 2018 #6, MT2 2017 #1, MT2 2014 #2

Ideal gas process with some external force or change in potential energy: MT2 2014 #1, MT2 2016 #1, Tutorial 6 problem 2

Ideal gas problems with efficiency: Tutorial 6 problems 1,3, Tutorial 7 #2, MT2 2017 #2, HW6 written,

2) Problems involving radiation: do 1-7 below and then practice problems

The following questions contain the basic skills that you will need to employ:

1) A star emits radiation with peak wavelength 600nm. What is its temperature?

2) The star in the previous question has radius 10^6km. What is its total power?

3) If we are 10^8km from that star, what is the intensity of radiation?

4) If a perfectly absorbing spherical object of radius 1m and albedo 0.7 is 10^8km from that star, how much energy does it absorb per time?

5) If we move that object 2.7 times further away, what is the new intensity at that location relative to the old intensity?

6) A spherical satellite of radius 6m is 300K on the side facing the sun and 150K on the other side. If e=0.8 for the object, what is the heat current for radiation from the object.

7) Given a spectrum graph for an object (with vertical axis W/nm and horizontal axis nm) how would you find the power of radiation between 200nm and 300nm?

Many of the detailed problems want you find an equilibrium temperature of something. Here, the key point is that when the temperature of an object is not changing, the net heat current into that object must be 0, so $H_{in} = H_{out}$. So you need to calculate all the ingoing heat currents and all the outgoing heat currents and set them equal.

Best problems for practice:

Midterm 2 2018, question 7

The radiation practice problems in “Midterm Resources” on Canvas (the last one is Tutorial 7 #1)

Radiation formulae:

Wien’s Law: $\lambda_{max} = b/T$ $b = 2.90 \times 10^{-3}$ m K. Power in radiation: $H = A \sigma e T^4$
Intensity is energy per time per area.

Intensity at distance R from a spherical source: $I = H/(4 \pi R2)$

This means that $I_2/I_1 = (R_1/R_2)^2$

3) Multiple choice questions:

Go through the sample multiple choice questions in the Midterm 2 resources section on Canvas:

Midterm 2 2018 multiple choice

"Entropy Multiple Choice" (do after Nov 1)

"Multiple Choice Practice"

"More Multiple Choice Practice"

(I'd prioritize them in this order if your time is limited). If you're not totally sure about one of the answers ask someone for further clarification or post a question on Piazza.

Things you need to know about entropy:

-for an infinitesimal process $dS = dQ/T$.

-heat is the area under the curve of a TS diagram, with positive heat if S is increasing

-total entropy for a system never decreases, but entropy for certain parts can decrease

-entropy is a state variable, so $\Delta S = 0$ for a complete cycle, and ΔS is the same for any path between the same two endpoints.

-The efficiency of an engine cycle plotted on a TS diagram is the area inside the cycle divided by the total area under the parts moving to the right.

For practice, try the sample multiple choice questions on entropy on Canvas, and MC questions 4 and 5 from the 2018 midterm.