ANSWER KEY TO MIDTERM 2014
PRACTICE QUESTIONS

1a. Y = visible light part of spectrum 1b. Z = infrared part of spectrum 1c. X = UV part of spectrum

2. (c) since there are 3 electrons depicted in the atom, and it is neutral, then there have to be 3 protons in the nucleus. *[see p 19 in Class Notes for a review]*

3. (d) when energy is absorbed by an electron, it leaps to a higher energy level. *Remember that an electron is MATTER, while a photon is ENERGY -- the MATTER does the absorbing and emitting, while the PHOTON of energy is the thing that IS absorbed or emitted.*

4. FALSE We haven't yet talked much about the ozone hole -- this is NOT how it works or why it is important so the statement is false. But have you pieced together in your mind how the Earth DOES cool?? ANSWER: The earth cools by radiating a great deal of its infrared (IR) radiation out to back out to space through the IR Atmospheric Window!

5. TRUE 6. (d) see p. 43 in SGC-E-Text Chapter 3: section on Planetary Energy Balance

7. (a) this is just the inverse of the "mantra quote" in the box on the bottom of p 25 of Class Notes (below the cartoon with the rope being shaken): "The shorter the wavelength the greater the energy & the higher the frequency"

8. (c)

9. (d) *[See the section on "Physical Causes of the Greenhouse Effect" on pp 48-50 in SGC-E-Text Chapter 3 for a review of this concept]*

10. (c) see the section in SGC-E-Text referred to for #9 above.

11. (b) see p 37 in Class Notes and the Table 3-2 and 3-3 in SGC-E-Text

12. (b) Remember that short wavelengths, high frequency, and high energy all go together, and be sure you understand that ultraviolet (UV) wavelengths are *shorter* than infrared (IR) wavelengths. Another key thing to remember is that **ONLY infrared (IR) energy is involved in the Greenhouse Effect!!**

13. (d) This one takes careful reading. There is something wrong in every choice but (d). Choices (a) and (c) both imply that that long wavelengths and hot temperatures go together, but you should remember that Wein's Law is an *inverse* relationship between wavelength and temperature, so they can't be correct. Choice (b) describes the relationship between wavelength and radiation intensity (energy flux), *not* temperature, hence it is also incorrect. That leaves choice (d) which is the "mantra" for Wein's Law.

[TEST-TAKING HINT: Note that in Question #13 the phrases **bolded** are there ***to help you sort through similar sounding phrases.*** Look for clues like this in the real exam and TAKE YOUR TIME so you can sort out the correct answer logically based on what you know and clues that are given in the question.]

14. (c) Using the logic described above, only (c) relates **wavelength** (lambda) with **temperature** in an **inverse** relationship.

15. (d) To answer this one correctly you must understand the underlying principle of absorption curves. Each curve represents the wavelengths that are absorbed easily by a specific substance (usually a gas) or group of gases. Not all substances absorb and emit the same wavelengths of energy, even if the temperature of the substance is exactly the same. It's true that (a), (b), and (c) are all correct statements based on the radiation laws, but **only (d) gets to the essence of why different gases have different absorption curves.**

16. (c) infrared radiation To answer this correctly, you have to know the "micrometer boundaries" of UV (< 0.4), visible (0.4 - 0.7) , and IR (> 0.7) part of the spectrum and also know that the microwave part of the spectrum begins at much longer wavelengths than those depicted in the figure (at about 100 micrometers)

17. (c) both solar and terrestrial Graph B is the graph of absorption by ozone gas. It shows that ozone can absorb harmful UV wavelengths (which is why the ozone layer in the stratosphere is beneficial) and it can also absorb IR wavelengths (which is why ozone can also be considered a greenhouse gas).

[NOTE: Ozone enters into Global Change issues in two different ways: (1) as a factor in the ozone layer and the ozone "hole" issue (which we'll be covering later), and (2) as a greenhouse gas. ***These are TWO VERY DIFFERENT ISSUES with very different processes involved!*** *The key to understanding the difference between the two issues is in the dual properties of ozone absorption -- the fact that ozone is a greenhouse gas that absorbs IR radiation is a totally DIFFERENT property than its additional ability to absorb in the UV part of the spectrum!!!! Don't confuse these two things!!!]*

18. (c) Here you have to be familiar with the wavelengths of maximum emission of energy by both the Sun (0.5 micrometers in the middle of the visible light part of the spectrum) and the Earth (10.0 micrometers in the infrared (IR) part of the spectrum. Choice (d) states things backward with respect to the greenhouse effect. Choice (e) may sound like the right answer, but remember that the Sun radiates in ALL wavelengths, not just visible light.

19. (b) 20. (c) 21. (a) review p 42 in Class Notes

22. (b) You can figure this one out if you remember that the shortest wavelengths are the most harmful because they contain the highest frequency wavelengths of electromagnetic energy. You also need to remember that the ozone layer absorbs the most harmful wavelengths of UV radiation (UVC and some UVB), but not UVA. See also Arrows 3 & 4 in the figure on p. 36 of Class Notes. UVC radiation is very harmful, and luckily both UVC and most of the UVB are absorbed by gases in the atmosphere BEFORE they reach the Earth's surface. UVA (and actually some more harmful UVB) gets through the atmosphere to the surface, which is why we need sunscreen!

23. Troposphere 24. Stratosphere 25. Mesosphere 26. Thermosphere

[HINT: if this appears as a multiple choice question, don't get thrown off by similar sounding, but incorrect choices such as: *tropopause, stratopause, "menopause"* etc. etc.

27. (c) It's not (a) because atmospheric pressure decreases with altitude (see Fig 3-9a in SGC-E-Text). It's not (b) because CO_2concentration (as well as the concentration of all the other GHG's except for ozone) is highest in the troposphere. It's not (d) because temperature is warmest at the Earth's surface and then decreases through the troposphere -- this figure shows the highest values are in the stratosphere.

28. (b) Is the best answer - quasi-periodic oscillations with an increasing trend

29. (b) The flat (horizontal) portions of the graph represent the fact that heat energy in calories is being absorbed by the H_2O but the temperature of the H_2O is not increasing as this happens. Instead, the energy is going into the *phase change process*. Since this energy is not sensed as a temperature increase, it is l**atent (or hidden) energy (LE**). The slanted portions of the graph (U-V, W-X and Y-Z) represent **sensible heat (H)** -- the energy that is heating up 1 gram of H_2O at the rate of 1 degree C for every 1 calorie of energy absorbed. H can be "sensed" with a thermometer, but LE can't. *[see p 52 in Class Notes for a review.]*

30. (a) **convection** is defined as the transfer of energy by means of large-scale movements of matter (recall that *conduction* is molecule-to-molecule transfer of energy (with the molecules not changing position) and that the transfer of energy as LW (infrared) radiation or SW (UV or visible light) radiation occurs as electromagnetic waves which can transfer energy without matter.
IMPORTANT: Don't confuse outgoing IR radiation with rising warm air! **Infrared (IR) is energy,** NOT moving warm air -- the IR energy is NOT sensed as heat or warmth until it is ABSORBED by something (e.g., greenhouse gas molecules, etc.)

31. (d) incoming shortwave energy (UV, visible light) is transferred as photons or pulses of energy

32. (b) **the sand will heat up faster and get hotter than the water because it takes less energy (in calories) to change its temperature.** (It will also cool off faster than the water) Remember that because of its high specific heat and heat capacity, water takes longer to heat up, but once heated up, it will *hold that heat longer.* Substances with lower specific heats and heat capacities (like air and soil) respond more readily to changes inputs of energy than water and heat up and cool off faster.

33. (c) Figure X implies that the IR/ longwave (LW) terrestrial radiation is being reflected back to the Earth's surface. What really happens is that the IR radiation is absorbed by the Greenhouse gases (GHGs) in the atmosphere, and then radiated back down to the surface. As discussed in class, both Y and Z show the absorption and re-radiation of IR, but Y also has part of the incoming shortwave (SW)/Solar radiation circled. The Greenhouse Effect (GHE) involves ONLY INFRARED radiation, so circling some of the Solar / SW makes Y an incorrect choice. **HINT:** If you are asked to circle the part of the figure that represents the GHE, be careful that you circle only the Terrestrial IR/LW radiation part of the figure and not some of the Solar/SW too!

34. (c) We learned that a well-designed LED (light emitting diode) bulb can be up to 80 % efficient, which means that the thermal energy lost due to inefficiency will be 20%. The input of energy to a light bulb is electrical energy.

35. (a) *The Law of Conservation of Energy is the same thing as the 1st Law of Thermodynamics]*

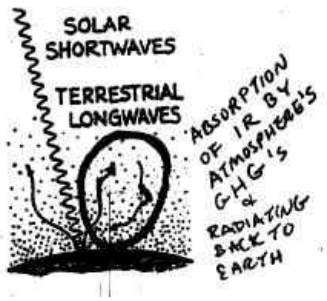
36. (d) Look closely at the figure! The thermal energy flow is going **from** the cold ice cube **to** the warm finger and this violates the 2nd Law of Thermodynamics!

END OF MULTIPLE CHOICE PRACTICE QUESTIONS

SAMPLE ESSAY QUESTION (and a few more multiple choice too!)

37a. Of the 3 figures shown, Figure Y displays the best representation of the Greenhouse Effect (although note that it doesn't represent ALL the pathways of SW and LW that are discussed on the bottom of page 33 in Class Notes..)

37b. (see sketch below) Be sure you do NOT circle any of the SW radiation part of the figure -- the GREENHOUSE EFFECT involves LW (Infrared) radiation ONLY



37c. *(Be sure to explain WHY X and Z are incorrect in addition to saying WHY Y is more accurate.)*

Figure X depicts all terrestrial LW radiating right back out to space;

Figure Z implies that the terrestrial LW is REFLECTED back down to the Earth's surface -- this is NOT what happens!

Figure Y is more accurate because it shows the LW being ABSORBED by gases in the atmosphere and then being RADIATED (not reflected) back to the Earth's surface.

37d. Here's the definition given in the Midterm Study Guide (under Topic #5): "The greenhouse effect is the natural mechanism by which the Earth's surface is warmed by infrared-absorbing gases (i.e. greenhouse gases) in the atmosphere."

NOW, work on your OWN wording of the concept -- don't just memorize or repeat the above. Avoid words like "bounce" or "reflect" whenever you are discussing longwave infrared radiation! Instead be sure to make the point that the greenhouse gases absorb IR and then radiate it (emit it) out again. Also, don't get confused in your words and start talking about the greenhouse gases being absorbed! The gases do the absorbing and emitting of the IR radiation, they are NOT absorbed themselves.

38. (a) troposphere

39. *[For the answer, see p 35-36 in Class Notes and the discussion on the Structure of the Atmosphere in SGC-E-Text Chapter 3.]* The **troposphere** decreases in temperature with height because it is primarily heated from below by terrestrial infrared energy radiating upward from the Earth's surface. The **stratosphere** increases in temperature with height because the ozone layer is in the stratosphere and the higher you go in the stratosphere the more incoming UV there is to be absorbed by ozone (and oxygen). When these gas molecules absorb the high energy UV radiation, they are energized and move faster ("jiggle" more) and hence the atmosphere warms up at this level. (Note however that the air in the stratosphere is much less dense than the air in the troposphere.)

40. This question is one that asks you to apply concepts you've learned to a less familiar topic: the Kramer Junction solar plant in the *Saved by the Sun* video.

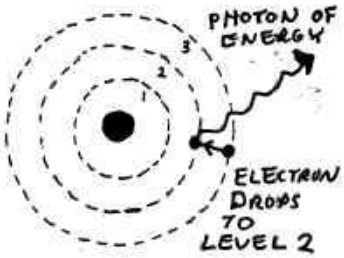
(a) **ENERGY is transferred** from X-to-Y (from the SUN to the SYNTHETIC OIL in the red tubes) by **RADIATION**

(b) When water in the **Solar Super-heater vat** boils instantly, the Y-to-Z heat transfer that occurs can be described as the transfer of **SENSIBLE HEAT** in the SYNTHETIC OIL to **LATENT HEAT** in the STEAM .

NOTE: There are lots of energy transfers going on this solar thermal plant!! I selected some of the most basic ones to ask about in this question.

Do you have a feel for how does this kind of solar energy technology differs from a photovoltaic cell? **ANSWER:** a photovoltaic cell involves photons from the sun being absorbed by a silicon layer and "knocking loose" the electrons from their atoms in the silicon layer so that electricity can be generated. (If you are curious and interested in learning more details for your Linking-to-Life Project, see: http://www.pbs.org/wgbh/nova/tech/how-solar-cell-works.html and http://www.pbs.org/wgbh/nova/tech/solar-tech.html

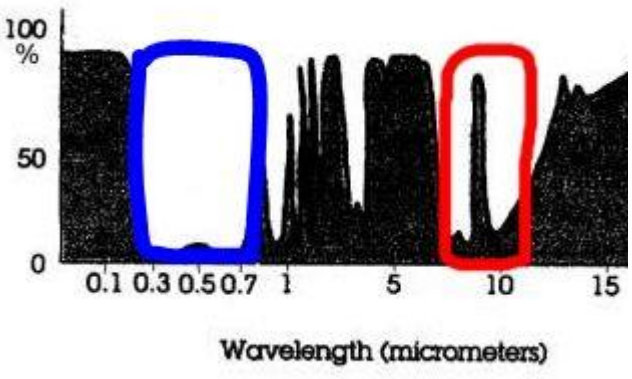
41. (see sketch below) *(If you get a question like this, be sure your follow all the directions and **LABEL** your sketch (as shown below) in addition to just drawing in the answer.)*



NOTE: Be sure that you depict the **ELECTRON leaping between energy levels**, NOT a photon! The electron emits or absorbs a photon of energy, not the other way around. Also be sure you show the photon being EMITTED if the electron leaps to a LOWER energy level. (Or, if the question asks you to show what happens when a photon is ABSORBED, show that the electron leaps to a higher energy level.)

42. The sketch below represents a hypothetical atmosphere in which ALL UV is absorbed, while all VISIBLE & IR radiation is transmitted, or allowed to get through the atmosphere:

43a. **UV+Visible Atmospheric Window:** See the blue line. You should have a circle around the open (not black) areas in the part of the spectrum that is roughly around the range of 0.3 - 0.7 µm in the shortwave part of the spectrum.



WHY is this wavelength range referred to as an "atmospheric window

Think about what a regular glass window does (allows light to pass through it.) Know that "light" is a general term sometimes used for electromagnetic radiation or energy involving photons, whether the radiation is UV or visible or even IR -- then proceed with an explanation based on that.

43b. **IR Atmospheric Window:** See the red line. You should have a circle around the open (not black) areas in the part of the spectrum that is roughly around 8 - 12 µm. Note that there is one "spike" of absorption that takes place right in the middle of the 8 - 12 µm IR atmospheric window at ~ 9.6 µm.. This absorption is caused by the gas ozone. (See p 49 in SGC-E-Text and the caption for Fig. 3-13)

Why is it so important for the Earth's Energy Balance?

First remember that the UV/Visible window allows incoming solar (UV and visible) radiation IN to be absorbed by the Earth's surface, the IR window allows outgoing terrestrial IR radiation OUT to space. Then proceed with explaining why the IR window is important for the overall Energy Balance and the temperature of the Earth that depends on that balance.

44 . (a) the **land surface** would be hotter. See the table on p 41 in Class Notes and the Q's at the bottom of that page. Land (made up of substances like sand and rock) has a lower specific heat than water, so that it takes less thermal energy to heat up the land than the water. Therefore the land responds quickly to the solar energy input and will **heat up faster** than the water in the lake with the same amount of energy coming in during the day. There might be other factors involved too related to the differences between land vs. water . . . but the ro of specific heat is a key point that should be made.

Would the LAND surface still be hotter than the LAKE surface at dawn the next day?
Water heats up more slowly, but once it does heat up, it holds that heat longer than the land due to its higher heat capacity -- so after the Su goes down and no more solar energy is being received by either surface, think about which one will still be holding a lot of heat at the end of night. (An analogy is the "hot apple pie" example in the cartoon on p 41 in Class Notes.)

45. See class notes and the Class Follow Up for Topic #8 for the answer.

46. c This is essentially the same question as #31, but with one of the symbols of the Energy Balance Equation as a choice.

To explain your answer you could explain the difference in the type of form of the energy involved in choice (c) compared to each of the oth

47. To answer this, the points you could bring up are: Trucks have larger mass, therefore they have more inertia, and more fuel will be needed to get them moving (1st Law) . Also once a big truck IS moving, it will keep moving and have more momentum, To get a massive truck (m) moving from a stop, it needs to accelerate (a) which takes a large amount of force (f) and the energy for thatt force comes from fuel consumption. (2nd Law)