

TSOKOS READING ACTIVITY
Section 8-2: Thermal Energy Transfer (8 points)

1. Essential Idea: For simplified modeling purposes the Earth can be treated as a black-body radiator and the atmosphere treated as a grey-body.
2. Nature Of Science: Simple and complex modeling: The kinetic theory of gases is a simple mathematical model that produces a good approximation of the behavior of real gases. Scientists are also attempting to model the Earth's climate, which is a far more complex system. Advances in data availability and the ability to include more processes in the models together with continued testing and scientific debate on the various models will improve the ability to predict climate change more accurately.
3. International-Mindedness: The concern over the possible impact of climate change has resulted in an abundance of international press coverage, many political discussions within and between nations, and the consideration of people, corporations, and the environment when deciding on future plans for our planet. IB graduates should be aware of the science behind many of these scenarios.
4. Theory Of Knowledge:
 - a. The debate about global warming illustrates the difficulties that arise when scientists cannot always agree on the interpretation of the data, especially as the solution would involve large-scale action through international government cooperation.
 - b. When scientists disagree, how do we decide between competing theories?
5. Understandings:
 - a. Conduction, convection and thermal radiation
 - b. Black-body radiation
 - c. Albedo and emissivity
 - d. The solar constant
 - e. The greenhouse effect
 - f. Energy balance in the Earth surface–atmosphere system
6. Applications And Skills:
 - a. Sketching and interpreting graphs showing the variation of intensity with wavelength for bodies emitting thermal radiation at different temperatures
 - b. Solving problems involving the Stefan–Boltzmann law and Wien's displacement law
 - c. Describing the effects of the Earth's atmosphere on the mean surface temperature
 - d. Solving problems involving albedo, emissivity, solar constant and the Earth's average temperature
7. Guidance:
 - a. Discussion of conduction and convection will be qualitative only
 - b. Discussion of conduction is limited to intermolecular and electron collisions

- c. Discussion of convection is limited to simple gas or liquid transfer via density differences
- d. The absorption of infrared radiation by greenhouse gases should be described in terms of the molecular energy levels and the subsequent emission of radiation in all directions
- e. The greenhouse gases to be considered are CH₄, H₂O, CO₂ and N₂O. It is sufficient for students to know that each has both natural and man-made origins.
- f. Earth's albedo varies daily and is dependent on season (cloud formations) and latitude. The global annual mean albedo will be taken to be 0.3 (30%) for Earth.

8. Data Booklet Reference:

- a. $P = e\sigma AT^4$
- b. $\lambda_{max}(meters) = \frac{2.90 \times 10^{-3}}{T(kelvin)}$
- c. $I = \frac{power}{A}$
- d. $albedo = \frac{total\ scattered\ power}{total\ incident\ power}$

9. Utilization:

- a. Climate models and the variation in detail/processes included
- b. Environmental chemistry (see Chemistry option topic C)
- c. Climate change (see Biology sub-topic 4.4 and Environmental systems and societies topics 5 and 6)
- d. The normal distribution curve is explored in Mathematical studies SL sub-topic 4.1

10. Aims:

- a. Aim 4: this topic gives students the opportunity to understand the wide range of scientific analysis behind climate change issues
- b. Aim 6: simulations of energy exchange in the Earth surface–atmosphere system
- c. Aim 8: while science has the ability to analyse and possibly help solve climate change issues, students should be aware of the impact of science on the initiation of conditions that allowed climate change due to human contributions to occur. Students should also be aware of the way science can be used to promote the interests of one side of the debate on climate change (or, conversely, to hinder debate).

11. Read section 8-2, pgs. 329-337, in your textbook.

12. Answer the following questions:

- a. What are the three methods of heat transfer?
 - i. _____
 - ii. _____
 - iii. _____
- b. Define conduction. _____

- c. Define convection. _____

- d. Define radiation. _____

- e. In what form of energy do all bodies that are kept at some absolute temperature radiate? _____

- f. What law governs the power radiated by a body? _____
- g. State the Stefan-Boltzmann law. _____

- h. State the equation for the Stefan- Boltzmann law. _____
- i. State the variable and the value for the Stefan- Boltzmann constant. _____
- j. What does the “ e ” stand for in the Stefan- Boltzmann equation and what is it? _____

- k. What is the emissivity of a perfect emitter (aka **black body**)? _____
- l. Give three characteristics of a black body.
i. _____
ii. _____
iii. _____

- m. What are the characteristics of a surface that has a high emissivity and what are those that have low emissivity _____

- n. What is the net rate (in equation form) that energy will be absorbed or emitted by a body?

- o. Bodies absorb energy at the same rate (same formula) at which they emit energy. What is required for a body to remain at equilibrium? _____
- p. What is Wien’s Law and what is the equation for it? _____

- q. What variable determines the wavelength at which most of the energy is emitted by a body? _____

- r. What change in this variable will increase wavelength? _____
- s. How will a decrease in temperature affect an intensity versus wavelength graph for a given body?

- t. For bodies with different emissivities (ϵ) that are kept at the same temperature, what is the difference in their plots on an intensity versus wavelength graph? _____

- u. The military and law enforcement use a device utilizing this principle to find people in the dark. What is the name of this device? _____
- v. What is the power output of the sun? _____
- w. We consider the sun to be a perfect emitter ($\epsilon = 1.0$) and that it emits its power spherically. What is the definition, variable used, equation for a spherical emitter, and units for '*intensity*'? (the number of items you must give make this a very intense question)

- x. Define 'solar constant' and give its value. _____

- y. What is the relationship between power (P) and intensity (I)? _____
- z. What is the *albedo* of a body and what variable is used for it? _____

- aa. What is the average global albedo of the earth? _____
- bb. What factors affect the albedo of a given area on earth? _____

- cc. What is the average intensity of the sun's radiation is received on the earth's surface (i.e. after reflection by the earth's surface)? _____
- dd. From Worked Example 8.10, what is the global day and night average temperature of the earth's surface in Kelvin and Fahrenheit? _____
- ee. What temperature (Celsius and Fahrenheit) did the simplified Energy Balance model/equation in Figure 8.20 produce in Worked Example 8.10? _____
- ff. What constitutes the biggest difference between the simplified Energy Balance model/equation and the Worked Example 8.10 and reality (this is the essence of the greenhouse effect)? _____

gg. List three other drawbacks to the simple model in Figure 8.20, i.e. things the model does not consider.

i. _____

ii. _____

iii. _____

hh. According to Wien's law, if the earth's average surface temperature is 288K, what part of the electromagnetic spectrum do the wavelengths of energy radiated from the surface fall under? _____

ii. What is the difference between visible light wavelengths coming from the sun and infrared wavelengths radiated from the earth in terms of passage through the earth's atmosphere? _____

jj. What is the name for the gases that absorb and re-emit the infrared radiation from the earth's surface? _____

kk. Do these gases actually reside in green houses? _____

ll. Define the *greenhouse effect*. _____

mm. What are the gases primarily responsible for the greenhouse effect? (and don't say greenhouse gases!) _____

nn. Should we try to completely eliminate the greenhouse effect? _____

oo. What do we have to worry about in terms of the atmosphere? _____

pp. What is a 'sink' (not the kind you wash your hands in)? _____

qq. Will you be familiar with the most common greenhouse gases and their sources as given in Table 8.4 when it comes to the test/IB exam? _____

rr. The energy levels of molecules are due to their _____

ss. The difference between molecular energy levels is approximately equal to _____
_____. This means that _____

tt. What happens when gas molecules absorb infrared energy photons? _____

uu. Are all the emitted photons radiated back toward the earth? _____

vv. Warming of the earth due to enhanced greenhouse gases will cause more water to evaporate from the oceans. Will this cause the earth's temperature to increase or decrease? Give an example of positive feedback and negative feedback (not to me, to the earth's temperature).

i. Negative Feedback: _____

ii. Positive Feedback: _____

13. Answers may be typed or neatly printed. Drawings may be freehand, but try to make use of the 'Shapes' or 'Insert Clipart' functions of MS Word. If you submit this assignment electronically, the filename must be in the following format, "LastnameFirstinitialPerXReadActX-X".