Equations & conversions factors: 
\[ \frac{Q}{t}_{\text{cond}} = \frac{\text{Area} \times (T_H - T_C)}{R} \]

\[ \frac{Q}{t}_{\text{nf}} = \frac{(\text{air change}/H) \times (\text{Volume}) \times (0.18 \text{ Btu/ft}^3 \text{F}^{-1}) \times (T_H - T_C)}{\text{DD}} \]

\[ KE = \frac{1}{2} mv^2 \quad \text{DD} = 65 - T_{av} \quad T_{av} = \frac{T_{high} + T_{low}}{2} \quad 1 \text{HP} = 550 \frac{\text{ft} \times \text{lb}}{\text{s}} \quad Q = mc \Delta T \]

Do you know your final project yet? Choose from lab project (LP), term paper (TP), or short oral presentation (SOP): Which? Any idea for a title???
9. (1 ½) Three types of “Light Water Reactors” are ____, ____, and ____.

10. (1 ½) (a) Where is a commercial “Heavy Water” reactor found? ____________________________
(b) What is it called? ____________________________
(c) Does it also use enriched $^{235}$U?

11. (1) A type of reactor pioneered in France and Great Britain that initially uses fuel that consists of natural uranium and $^{239}$Pu and will actually produce more $^{239}$Pu fuel than it uses is called a ____ reactor.

12. (1) Under the fear of Germany producing a nuclear weapon before any other country during WWII, the United States embarked upon a secret, crash program to build an atomic bomb before Germany. This crash program was called the ____.

13. (1 ½) In the aftermath of WWII, the United States, under President Eisenhower, embarked upon a massive “Atoms for Peace” program and, in turn, envisioned a “Great Nuclear Society.” This program consisted of three stages of nuclear power: ____, ____, and ____.

14. (1 ½) List the three world-wide major nuclear reactor accidents that occurred and that have contributed to a major negative reaction to the use of nuclear power.

15. (1) The country that has the greatest percentage of electricity from nuclear power is the country ____. In fact, the people living in this country seem to be quite comfortable with nuclear power.

16. (1) A “D-T reaction” refers to a process for (a) two electrons colliding (b) two neutrons colliding (c) two protons colliding (d) nuclear fission (e) nuclear fusion (f) none of the previous answers.

17. (1) A type of reactor that does not use neutron moderation but instead uses liquid sodium in order to carry away the heat is called a ____ reactor.

18. (1 extra credit) If there is a nuclear accident and a release of radioactive materials, why is there such a concern for radioactive iodine-131 as compared to all the other radioactive fission fragments and heavy radioactive nuclei that exist in nuclear waste?

19. (1) What can people do to protect themselves from an accidental release of this iodine-131?

20. (1) In 1994 in MN for the two PWRs that are operational at Prairie Island, there was no longer room for the spent fuel rods in the storage pool! Under an agreement between the state of MN and the local utility at that time (Northern States Power), all used fuel rod assemblies that were greater than 10 years old could be removed from the storage pool and stored in ____.

21. (1) The power output of a typical coal-fired power plant or a typical nuclear power plant is _____. (Include units!)

22. (2) A general type of heat transfer which refers to energy emitted by a hot object in the form of electromagnetic rays is called _____. This heat gain resulting from sunlight shining in through the windows of a home is called _____.

23. (1) A general type of heat transfer which refers to heat passing through a substance without a change in shape of the object is called _____.

24. (1) If an attic is not properly ventilated, what major negative outcome results?
25. (2) A general type of heat transfer which refers to heat carried by the actual motion of a fluid (water or air) is called ___. This heat transfer as applied to a home where heat is lost out through the cracks and other openings of a house is called ___.

26. (1) The average evaluating factor for a MN home is about ___. (Include units)

27. (1) Which is better: a low evaluating factor or a high evaluating factor?

28. (1) Which of the following has the greatest resistance to heat flow? (a) 1 inch of softwood, (b) 1 in. of insulating board, (c) 1 in. of stone, (d) 1 in. of fiberglass, (e) a single pane of glass

29. (3) If a triple-pane glass window has an R-value of 3.0, determine how much heat would pass through a large 4.0 ft by 12.0 ft window in one day if the temperature on the outside of the window is 25°F and the temperature on the inside is 75°F. Enter: $Q = \frac{\text{Area} \times (T_{\text{out}} - T_{\text{in}})}{R}$

30. (3) The number of air changes per hour in a tight house is ___. However, if the number of air changes per hour is less than a “threshold” limit of ___, then the condition is dangerous! Why? Not enough oxygen or fresh air. One can suffocate.

31. (1) Heavy materials like concrete, masonry, and water have a high ___. in that they store a lot of heat and allow temperatures inside the house to remain in a comfortable temperature range.

32. (2) Two competing heat transfer processes occur for the south-facing windows of a home: one of these is heat gain from ___, the second of these processes results from heat loss due to ___.

33. (1) For the above question, the window of choice for south-facing walls that maximizes the heat gained and minimizes the heat lost by the before-mentioned competing processes is (a) a single-pane window, (b) a double-pane window, (c) a triple-pane window, (d) a quadruple-pane window.

34. (3) On Jan. 1, 2017, the high temperature was 40 deg F and the low temperature was 10 deg F. On Jan. 2, 2017, the high temperature was 10 deg F and the low temperature was -20 deg F. The number of degree days on Jan. 1 was ___, the number of degree days on Jan. 2 was ___, and the contribution for both days was ___. (Note: $TD = \frac{H + L}{2} \times (D - L)$)

35. (1) The amount of solar energy which the earth receives at the top of the earth’s atmosphere is about __ watts/m² while at the earth’s surface only about __ watts/m² is received.

36. (1) What fluid serves as a heat transfer agent that is pumped into the typical MN flat-plate collector in an active solar system? (If you don’t remember the name of the fluid, describe it for full credit.)

37. (1) The “geothermal gradient” is closest to (a) 25°C/km (b) 50°C/km (c) 75°C/km (d) 100°C/km

38. (1) A geothermal vapor-dominated based plant is ___ a geothermal water-steam based plant. Choose from: (a) more expensive than (b) less expensive than (c) very nearly the same price as

39. (1) The one of the best source of tides is La Rance River in France. However, the peak power output from this plant is closest to (a) 2.4 MW (b) 24 MW (c) 240 MW (d) 2400 MW (e) 24 kW (f) 24000 MW

40. (1) Flat-plate solar collectors are part of (a) an active solar system (b) a passive solar system (c) a pV solar collection system (d) a parabolic concentrator
41. (1) The largest pV cell array in the world today has a power output closest to (a) 100 W (b) 1000 W (c) 100 kW (d) 1000 kW (e) 10 M W (f) 100 M W (g) 1000 M W

42. (1) A “thermosiphon” is a passive solar system that is found all over the Middle East and is primarily used for _heating water_ (or simply hot water).

B. Longer Answer Questions

1. (4) List and discuss four advantages of nuclear power in the United States. Contrast that with four disadvantages.

   **Advantages**
   1. We will need more nuclear energy.
   2. Less foreign oil dependence.
   3. Less CO₂ produced.
   4. Chester than coal for existing plant.
   5. Concentrated energy.

   **Disadvantages**
   1. Possibility of major accident.
   2. Terrorism use of fuel.
   3. Public/Private transfer of radioactive material.
   4. Lifetime is limited.
   5. Nuclear waste disposal.

2. (2) (a) What happened at Chernobyl. (b) What kind of a reactor was this?

   (a) Electrical engineers turned off safety controls to do testing and went through an unstable region of operation

   (b) Graphite

3. (2) (a) (1) What happens when a neutron strikes a U²³⁵ nucleus? (b) (1) How does this pose a problem for us regarding potential terrorism?

   (a) Pu²³⁹ is produced

   (b) The Pu²³⁹ produced found in nuclear waste can be used to make a bomb.

4. (2) What happens when a neutron strikes a U²³⁵ nucleus?

   \[ n \rightarrow U²³⁵ \rightarrow ²³⁵V \rightarrow \text{fission fragments} \rightarrow O + \text{energy} \]

5. (2) What happens when a neutron strikes a Pu²³⁹ nucleus?

   \[ n \rightarrow ²³⁹Pu \rightarrow \text{fission fragments} \rightarrow O + \text{energy} \]

6. (5) (a) Pick one of the three types of light water reactors that we have discussed. List the type of light-water reactor that you have picked here: PWIR OR BWIR OR GRAPHITHE REACTOR.

   (b) On the back of this page, draw a diagram of and explain the operation of the light water reactor that you have chosen. Be sure to discuss in your explanation how the power output of the reactor is controlled.
7. (3) Define what is meant by the "envelope" of a house?

This is the "shell" or outer part of a heated living space that separates the warm inside from the cold weather (if winter) outside. This consists of the ceiling, outer walls, and basement floor.

8. (3) List and briefly discuss three specific examples of a passive heating system:

1. Have windows on south-facing side of home.
2. Few or no windows on north-facing side.
3. Build north side of home into hill.
4. Plant deciduous trees on south side.
5. Use properly designed overhangs on south side (or awnings) to keep the sun out during summer in winter.

9. (5) (a) (1) How is an active solar energy system different from a passive solar system? (b) (2) Draw a diagram of and explain the operation of an active solar energy system. (c) (2) Explain how this system can be used to heat a home using a "forced-air" heating system and how it can also be used to heat water.

(a) An active solar energy system requires a pump in order to drive the system. (Some outside form of energy is required!)

(b) Sun

(c) Flat-plate collector

Glycol

Pump

Storage

HOT 180°F

Heat WATER

Fan Forced Air Heating

Cold air is brought through cold air ducts, passes over hot coil & comes out into home via hot air ducts.

Water pumped into heat exchanger, is heated & is stored for later use.
10. Define **and** briefly discuss the following from the viewpoint of the text:

(2) **inertial confinement** is a form of nuclear fusion whereby many lasers surround a small pea-shaped shell that is filled with deuterium \( \text{H}_2 \) and tritium \( \text{H}_3 \) (alias D-T) when the lasers are simultaneously fired, they compress DT to fuse giving energy!

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**Example:** Copper pipe containing hot fluid.

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(2) **heat exchanger** is a coiled device whereby one fluid can transfer heat energy to another fluid.

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(2) **energy payback time** is the time in years that it takes for the cost of the installation of an energy saving device to pay for itself in energy dollars saved.

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(2) **power tower** are many mirrors on ground that direct the rays of the sun on to a central receiving tower boller. Water, passing through the boiler changes to high-pressure steam that drives turbine—generator and produces electricity.

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(2) **inverter** changes DC (direct current) output (from a PV cell) to AC (alternating current) for operation of home appliances.

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(2) **thermal mass** = mass x specific heat. A material with high thermal mass "holds" heat—i.e., the temperature will not change very much from day to night.

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(2) **Trombe wall** is a passive device for providing heat to a home.

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