Online Questions

1. A fireplace fire is usually orange, so we can surmise that its blackbody radiation is mostly in the infrared and visible portions of the electromagnetic spectrum. Since glass is (mostly) transparent in the visible spectrum, it must be that the glass absorbs infrared radiation, which we experience as heat.

2. There are a variety of ways to answer this question, but ~~the~~ some of the main things to mention are: the direct conversion ~~fro~~ of light to electric current, no moving parts, expensive initial investment, and the inconstant nature of solar energy (day/night, weather, etc.).

3. 1400 gallons of water weighs about $(8.35 \frac{lbs}{gal})(1400\ gal) = 11690$ lbs, which we need to heat up by 50°F

$\Rightarrow E\ (\text{in Btu}) = (11690\ lbs\ H_2O)(50°F) = 584500$ Btu. The collector at 50% efficiency only gives out 550 Btu/ft^2 as useful heat.

$\Rightarrow$ Area required $= \frac{584500\ Btu}{550\ Btu/ft^2} \approx 1063\ ft^2$ or roughly $100\ m^2$.

4. You have an 800 ft^2 concrete floor, with which you want to store 200,000 Btu with a 20°F difference.
From a variety of sources, the specific heat capacity of concrete is about $0.88\ \frac{J}{g \cdot K} \approx 0.21\ \frac{Btu}{lb°F}$, and it seems to have a density of roughly $2.3\ g/cm^3 \approx 144\ lbs/ft^3$

$$Q = mc_p\Delta T = \rho V c_p \Delta T = \rho A d c_p \Delta T$$

where m is mass, V is volume, d is thickness, ρ is density, A is area, c_p is the specific heat capacity, ΔT is the temperature change

$$\Rightarrow d = \frac{Q}{\rho A c_p \Delta T} \approx \frac{(200{,}000\ Btu)}{(144\ lbs/ft^3)(800\ ft^2)(0.21\ \frac{Btu}{lb°F})(20°F)}$$

$$\approx 0.4134\ ft \approx 5\ \text{inches}$$

5. So we have 20 m^2 of collecting area; let's assume a somewhat realistic efficiency of about 20%.
If we look up solar insolation data for San Diego, the numbers seem to be around $5000\ \frac{Wh}{m^2\,day} \approx 1825\ \frac{kWh}{m^2\,year}$

$\Rightarrow$ Total useful energy $= (0.2)(1825\ \frac{kWh}{m^2 yr})(20\ m^2) = 7300\ \frac{kWh}{year}$

6. With the numbers given, we can say an electric car has an overall efficiency of $(0.92)(0.9)(0.95)\underbrace{(0.38)}_{\text{coal plant efficiency}} = 0.2989 \approx 0.3$
A gasoline car has around 20% efficiency. So overall, the electric is better from an energetic viewpoint.

What about CO_2? From the EPA, 1 gallon of gasoline emits 19.4 lbs of CO_2 and releases 1.32×10^8 J
1 ton of coal emits 12892 lbs of CO_2 and releases 2.81×10^{10} J

Normalizing by energy: 1 gallon of gasoline $= \frac{1.32 \times 10^8}{2.81 \times 10^{10}}$ tons of coal $= 0.0047$ tons of coal $= 10.3$ lbs of coal

1 gallon of gasoline ↓ emits 19.4 lbs of CO_2; 10.3 lbs of coal ↓ emits 60.6 lbs of CO_2

So gasoline is more favorable! Note this calculation does not take into account the energy (and CO_2) it took to extract the gas in the first place!

Multiple Choice

3. c (the light our eyes adapted to see best in!)
6. b (from lecture slides)
7. $\Delta T = 40°C = 72°F$ (temperature difference!) $\Rightarrow Q = (22\ \frac{Btu}{ft^2 F})(72°F)(1000\ ft^2) = 1.6 \times 10^6$ Btu $\Rightarrow$ a
16. d (from page 112) 17. b (from page 116)