

Evaluation PHY555 Energy & Environment

Friday 16st December 2022

Part I, 5 points, recommended time 30 min

Student Name:

Note 1: Please write your answers directly on the subject sheet

Note 2: Don't forget to write your name at the top

Q1: Orders of Magnitude / Storage – You have in your possession a button cell (small, coin-sized battery) with the following characteristics: 200 mAh at a nominal voltage of 1.5 V, mass of 2.3 g, diameter of 2 cm. If you design a perfect system where all the energy of the battery is used to spin it like a flywheel, at what angular velocity would the battery spin?

Your answer:

Q2: Global Warming – If atmospheric CO₂ increases to 450 ppm, using the data of PC2, over what bandwidth (centered around 670 cm⁻¹) would atmospheric optical absorption due to CO₂ be greater than 50%?

Your answer:

Q3: **CCS** – Congratulations, you have invented a machine that can perform Direct Air Capture of CO₂ from the atmosphere (420 ppm). The machine has a 2nd law efficiency of 50% (it only requires twice the power to operate than the thermodynamic minimum). For the power source driving the machine, what must be the carbon intensity (kg_{CO2}/kWh) to break even in terms of atmospheric CO₂?

Answer:

Q4: **Thermal Machines** – You seek to build an electrical power generation station. You have access to a hot source at 350°C and a cold sink at 10°C. At what efficiency should the station be run to extract the maximum available electrical power?

Answer:

Q5: Nuclear – CANDU reactors use uranium with a very small fraction of ^{235}U . Why is it more critical for them than for other technologies to use heavy water as a moderator, rather than graphite or H_2O ?

Answer:

Q6: Insulation – A fashionable front door to a house is made of wood, 5 cm thick, and has dimensions of 80 cm x 220 cm. It has a small decorative window made of safety glass that is 10 cm x 30 cm and 8 mm thick. Using the information of PC6, how much more heat is lost through the window versus the rest of the door?

Answer:

Q7: **Wind** - In a well-designed wind turbine blade, the "chord" of the blade is thinner at the tips. Why is it so?

Answer, tick the right box(es):

- all parts of the blade face directly into the apparent wind
- the ratio between the lift and drag coefficient remains constant over the length of the blade
- the tangential force on the blade remains constant over its length
- to minimize the total mass of the blade
- it looks cool

Further comments:

Q8: **Solar** – A modern, commercial electric car consumes about 0.2 kWh/km. If the roof of such a car were to be covered in solar cells, under optimum conditions (sun directly overhead, using values calculated in PC 8), how fast can a solar-cell powered car travel (if the batteries were disconnected)?

Answer: