Please write your name and the last 4 digits of your OSU ID # below:

Physics 313 – Midterm test, Oct. 26, 2018

I. Multiple choice questions – 1 pt. each

1. In the Bingo County in the State of East Terracota there are two power plants, one generating 2 GW, and the other 60 000 kW of power. Their combined power output is:

(a) 2.6 GW;

(b) 260 MW;

(c) 206 MW;

→ (d) 2060 MW;

(e) 20060 MW;

1 GW = 1000 MW = 1000 000 kW

2 GW = 2000 MW

60 000 kW = 60 MW

2000 MW + 60 MW = 2060 MW

2. The combined maximum output of all power plants in the US is close to 1.1 TW. The power generated in each state is roughly proportional to the state's population. The Oregon's population is slightly larger than 1% of the total US population. One of the figures below gives the approximate value of the combined maximum output of all power plants in Oregon – choose the right one:

(a) 950 MW;

→ (b) 9,500 MW;

(c) 0.950 GW; → 950 MW

(d) 95 GW; → 95,000 MW

(e) 95,000,000 kW. → 95,000 MW

1 TW = 1000 GW

1% of 1.1 TW = 1% of 1100 GW = 11 GW = 1,1000 MW

(b) is the closest.

3. On the list below, the number *closest* to the Betz Limit value is:

(a) 24%;

(b) 38%;

→ (c) 60%;

(d) 79%;

(e) 91%;

(f) 90%.

Betz limit ≈ 59.2%

4. For capturing solar energy, Concentrated Solar Power (CSP) plants may use (mark the incorrect answer):

(a) An array of parabolic troughs;

(b) An array of photovoltaic (PV) panels; CSP plants do not use PV panels!

(c) A large circular parabolic mirror;

(d) A Fresnel mirror consisting of long flat mirror stripes;

(e) An array of flat movable mirrors.

5. The largest US pumped-storage hydropower plant is:

(a) On Colorado River (Hoover Dam);

(b) In the State of Oregon;

(c) Near Reno, Nevada;

(d) In the Bath County, Virginia; see Chapter 06

(e) In the State of Alaska;

6. At the current mining rate, the documented global oil and natural gas resources will last, approximately, for another period of:

(a) 10 years;

(b) 60 years; see chapter 03

(c) 220 years;

(d) 400 years.

7. The Solar Constant, $G_{SC} = 1.362$ kW/m^2, is the radiation power received by Earth from the Sun at the top of the atmosphere, per unit area on a theoretical surface perpendicular to the Suns rays. The average Earth's radius is roughly $R = 6371$ km. In order to calculate the total radiation power received by Earth at the top of its atmosphere (174 PW), one has to multiply G_{SC} by:

(a) $\frac{1}{2}\pi R^2$;

(b) πR^2; — see Chapter 07, pp. 170-71

(c) $2\pi R^2$;

(d) $4\pi R^2$;

(e) $\frac{4}{3}\pi R^3$.

8. The famous *Carnot Equation* states that $\epsilon = 1 - T_c/T_h$, but you are often asked to use a "formula with square root" instead: $\epsilon' = 1 - \sqrt{T_c/T_h}$. Why?

(a) Because Mr. Carnot had made a mistake in his original calculations, which was later corrected;

(b) Because ϵ' is the efficiency of output-work maximizing engine, and ϵ is the efficiency of output power maximizing engine – and we are usually interested in maximum work, not in maximum power;

(c) Because ϵ' is the efficiency of output-power maximizing engine, and ϵ is the efficiency of output-work maximizing engine – and we are usually interested in maximum power, not in maximum work; Chapter 03, p. 80.

(d) Because both formulas are approximations only, and ϵ' always yields a lower efficiency – it is always safer to take a lower estimate, than the higer – the higher may be an overestimate.

9. The Weniger Hall has a flat walk-out roof, exactly 20 m above the ground floor level. Going up the stairs to the roof, a person of a body mass of 80 kg will do the work of (take g as 10 m/s^2):

(a) 1600 J;

(b) 8000 J;

(c) 16,000 W;

(d) 16,000 W·s;

(e) 0.0444 kWh.

W is a unit of power.

1 W·s = 1 J : Energy expressed in terms of power and time, see Chapt 02, pp 12-13

10. The largest (as far as the maximum output power is concerned) hydropower plant in the US is:

(a) The Hoover Dam hydropower plant at Colorado River;

(b) The Niagara Falls hydropower plant;

(c) The Racoon Mountain hydropower plant;

(d) The Potomac River hydropower plant near Washington, D.C.;

(e) The Grand Coulee hydropower plant on Columbia River.

Chapter 05, Fig. 5.4 at p. 124

PROBLEMS

Problem A – 5 pts.
The air density at the summit of Mons Olympus ("mons" means "mount" in Latin), the highest mountain on the planet Mars, is 0.1% of the air density at the sea level on Earth. What is the speed of wind blowing over the top of Mount Olympus that carries the same power per square meter as a 10 m/s wind blowing at the sea level on Earth? (*Hint:* $P = \frac{1}{2} A \rho v^3$).

Eearth: $P_E = \frac{1}{2} \cdot 1\,m^2 \cdot \rho_E \cdot (10\,m/s)^3$

Mars: $P_M = \frac{1}{2} \cdot 1\,m^2 \cdot \rho_M \cdot v_M^3$

$\rho_M = 0.001\,\rho_E$: $0.1\% = 0.001$

Accordingly, if $P_M = P_E$:

$\frac{1}{2} \cdot 1\,m^2 \cdot \rho_E \cdot (10\,m/s)^3 = \frac{1}{2} \cdot 1\,m^2 \cdot 0.001\,\rho_E \cdot v_M^3$

$1000\,m^3/s^3 = 0.001 \cdot v_M^3$

$v^3 = \frac{1000}{0.001}\,\frac{m^3}{s^3} = 1{,}000{,}000\,\frac{m^3}{s^3}$

$\sqrt[3]{1{,}000{,}000} = 100$

So $v_M = 100\,m/s$

Problem B – 5 pts

The product sold by pharmacies as *rubbing alcohol* is a compound of a formula C_3H_8O. It's flamable. Write the equation of the combustion reaction of the substance, and calculate how much CO_2 is produced by burning one kilogram of C_3H_8O. *Hints:* The atomic masses of H, C and O are, respectively, 1, 12 and 16. For simplicity, at the left side of the reaction equation you may put the number of oxygen *atoms*, not necessarily the number of O_2 molecules.

chapter 03, pp. 58-63

$C_3H_8O + ?O \longrightarrow 3CO_2 + 4H_2O$

? : one atom; $3CO_2$: 4 atoms; $4H_2O$: 4 atoms

So, ? must be 7

Two ways of writing the reaction – both are correct:

$C_3H_8O + 3\frac{1}{2}O_2 \longrightarrow 3CO_2 + 4H_2O$

Mol. mass: $3\times12+8+16 = 60$; $3\times(12+2\times16) = 132$

So: $\frac{60}{1\,kg} = \frac{132}{x}$ $\Rightarrow$ $x = \frac{132}{60}\,kg = 2.2\,kg$

OR:

$2C_3H_8O + 7O_2 \longrightarrow 6CO_2 + 8H_2O$

tot. M. mass: $2\times60 = 120$; tot. M. mass: $6\times44 = 264$

So: $\frac{120}{1\,kg} = \frac{264}{x}$ $\Rightarrow$ $x = \frac{264}{120}\,kg = 2.2\,kg$