IB Physics Topic 8 – Energy Production. Part 2. Name ____

1. Below is the nuclear equation for fission of Uranium-235. What element is missing?

$$^{235}_{92}U \quad + \quad ^{1}_{0}n \quad \rightarrow \quad \_\_\_\_\_\_\_\_ \quad + \, ^{90}_{36}Kr \quad + 2\,^{1}_{0}n$$

Ans. (superscripts must add up on both sides of arrow, 236), (same for subscripts, 92) 144 Ba 56, Barium

2. A reactor uses ^{235}U as its fuel. When a nucleus of ^{235}U absorbs a neutron, the following reaction takes place:

Show that the energy released is between 150 and 200 MeV.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{54}Xe + ^{90}_{38}Sr + 2\,^{1}_{0}n.$$

	rest mass $MeV\,c^{-2}$
$^{235}_{92}U$	2.1895×10^{5}
$^{144}_{54}Xe$	1.3408×10^{5}
$^{90}_{38}Sr$	8.3749×10^{4}
$^{1}_{0}n$	939.56

Ans. (rest mass must add up on both sides of arrow, 2.1980×10^{5} vs 2.19708×10^{5}) subtract, and get 182

3. Air of density 1.2 kg/m^3 is incident at a speed of 9.0 m/s on the blades (L = 7.5 m, each) of a wind turbine. Immediately after passing through the blades, the speed of the air is 5.0 m/s, and its density is now 2.2 kg/m^3. The turbine and generator have an overall efficiency of 72%. If the power extracted from the air by the turbine is given by $P_{ext} = P_{in} - P_{thru}$, Calculate (a) the power extracted from the air by the turbine, and (b) the electrical power output generated. [Hint: $P_{out} = (Eff.)\cdot P_{ext}$] Ans. (a) 53 kW (b) 38 kW

4. (Review) Given that when a car is driving at 80 km/h it is doing work against air resistance at a rate of 40 kW.

a) How far will the car travel in 1 hour? Ans. 80 km

b) How much work does the car do against air resistance in 1 hour? Ans. 1.44×10^{8} J

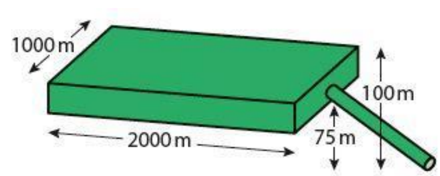
c) If the engine of a modern diesel car is 75% efficient, how much energy must the car get from the fuel? Ans. 1.92×10^{8} J

d) If the energy density of diesel is 45.8 MJ/kg, how many kg of diesel will the car use? Ans. 4.2 kg

e) If the density of diesel is 0.9 kg/L , how many litres will the car use? Ans. 4.7 L

f) Calculate the litres of fuel used per kilometre. Ans. .06 L/km

5. The diagram to the right depicts a volume of water stored in a lake at high altitude which is used to generate hydroelectric power.
Calculate (a) the total energy stored.
(b) power generated if water flows from the lake at a rate of 1.0 m^3/s.

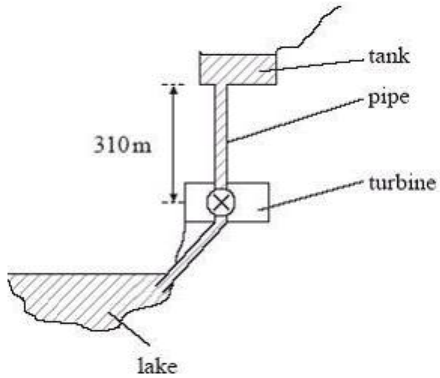


Ans. (a) 4.29×10^{13} J, (b) 857 kW

6. The maximum power output of the Drax coal-fired power station in the UK is 4.0 GW. Determine the minimum mass of pure U-235 (energy density = 82 TJ/kg) that would be required by a nuclear power station to provide the same maximum annual energy output as the Drax power station.

Ans. 1500 kg

7. The diagram to the right, not to scale, shows a pumped-storage power station used for the generation of electrical energy. Water stored in the tank is allowed to fall through a pipe to a lake via a turbine. The turbine is connected to an electrical generator. The pumped-storage AC generator system is reversible so that water can be pumped from the lake to the tank. The tank is 50 m deep and has uniform area of 5.0×10^4 m^2. The height from the bottom of the tank to the turbine is 310 m. The density of water is 1.0×10^3 kg/m^3.



(a) Determine the maximum energy that can be delivered to the turbine by the falling water.

Ans. (a) 7.6×10^{12} J

(b) The flow rate of water in the pipe is 400 m^3/s. Calculate the power delivered by the falling water.

Ans. (b) 1.3×10^{9} W

The energy losses in the power station are shown in the following table:

Source of energy loss	Percentage loss of energy
friction and turbulence of water in pipe	27
friction in turbine and ac generator	15
electrical heating losses	5

(c) Calculate the overall efficiency of the conversion of the gravitational potential energy of water in the tank into electrical energy.

Ans. 53%

(d) Draw a Sankey diagram to represent the energy conversion in the power station.