SECTION B

*This section consists of three questions: B1, B2 and B3. Answer **one** question. Write your answers in the boxes provided.*

B1. This question is in **two** parts. **Part 1** is about wind power. **Part 2** is about radioactive decay.

Part 1 Wind power

(a) Outline in terms of energy changes how electrical energy is obtained from the energy of wind. *[2]*

KE of Wind transfered to the KE of the blades....
.....
KE of the blades changed into electrical energy in the wind mill's generator.....

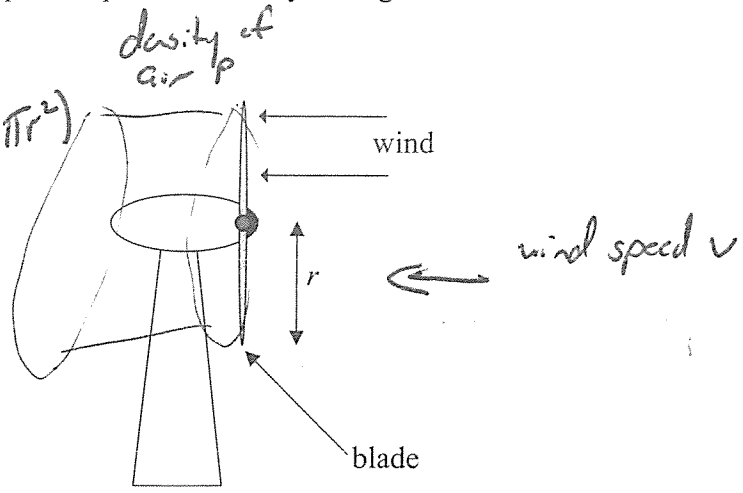
* Must mention generator for full credit

(This question continues on the following page)

(Question B1, part 1 continued)

(b) Air of density ρ and speed v passes normally through a wind turbine of blade length r as shown below.

(g) Density = $\frac{\text{mass}}{\text{volume}}$ ($V \cdot \pi r^2$)



(i) Deduce that the kinetic energy per unit time of the air incident on the turbine is

$$\frac{1}{2}\pi\rho r^2 v^3$$ *[3]*

From Stdyguide Pg 73

area 'swept out' by blades of turbine = πr^2
In 1 sec. the volume of air that passes the turbine = $V \cdot \pi r^2$
So mass of air that passes the turbine in 1 sec = $V \cdot \pi r^2 \cdot \rho$
$KE = \frac{1}{2}mv^2$ ... $KE = \frac{1}{2}(V \cdot \pi r^2 \rho) \cdot v^2$ or $KE = \frac{1}{2}\pi\rho r^2 v^3$

(ii) State **two** reasons why it is impossible to convert all the available energy of the wind to electrical energy. *[2]*

1: speed of wind can not drop to 0

2: Frictional losses in the turbine from moving parts

(resistance in wires)

(This question continues on the following page)

(Question B1, part 1 continued)

(c) Air is incident normally on a wind turbine and passes through the turbine blades without changing direction. The following data are available.

Density of air entering turbine	$= 1.1\,\text{kg m}^{-3}$
Density of air leaving turbine	$= 2.2\,\text{kg m}^{-3}$
Speed of air entering turbine	$= 9.8\,\text{m s}^{-1}$
Speed of air leaving turbine	$= 4.6\,\text{m s}^{-1}$
Blade length	$= 25\,\text{m}$

Determine the power extracted from the air by the turbine. *[3]*

$KE_{\text{Air Enter Turbine}}/\text{sec} = \frac{1}{2}\pi(1.1\,\text{kg m}^{-3})(25\,\text{m})^2(9.8\,\text{m/s})^3 = 1.0\times10^6\,\text{W}$

$KE_{\text{Air Leave Turbine}}/\text{sec} = \frac{1}{2}\pi(2.2\,\text{kg m}^{-3})(25\,\text{m})^2(4.6\,\text{m/s})^3 = 2.1\times10^5\,\text{W}$

In Out

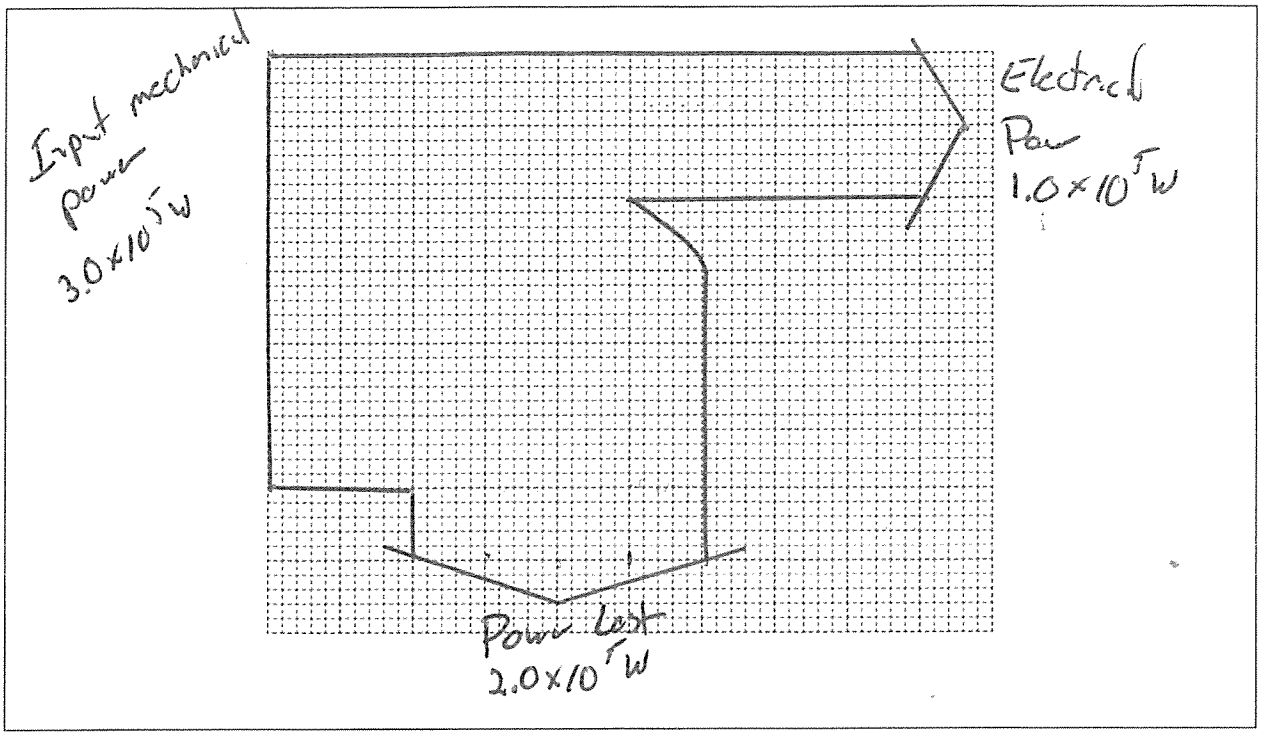
$\text{Power Extracted} = 1.0\times10^6\,\text{W} - 2.1\times10^5\,\text{W} = 8.1\times10^5\,\text{W}$

(This question continues on the following page)

(Question B1, part 1 continued)

(d) A different wind turbine has a mechanical input power of 3.0×10^5 W and generates an electrical power output of 1.0×10^5 W. On the grid below, construct and label a Sankey diagram for this wind turbine. *[3]*

Key 10 Boxes = 1.0×10^5 W



(e) Outline **one** advantage and **one** disadvantage of using wind turbines to generate electrical energy, as compared to using fossil fuels. *[2]*

Advantage: Clean - No harmful chemical byproducts
Source of Energy is free

Disadvantage: Source is unreliable - May be a day without wind
Low Energy density - Large area needs to be covered to produce significant energy

(This question continues on the following page)

(Question B1 continued)

Part 2 Radioactive decay

(a) Describe the phenomenon of natural radioactive decay. *[3]*

- Emission of Alpha / Beta / Gamma particles from the atomic nucleus
- The decay causes an instable atomic nucleus to become lighter and more stable

(b) A nucleus of americium-241 (Am-241) decays into a nucleus of neptunium-237 (Np-237) in the following reaction.

$$^{241}_{95}\text{Am} \rightarrow {}^{237}_{X}\text{Np} + {}^{4}_{2}\alpha$$

(i) State the value of X. *[1]*

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(ii) Explain in terms of mass why energy is released in the reaction in (b). *[2]*

According to $E=mc^2$ mass is converted to energy

Mass defect - Mass of the products is less than mass of the reactants

(This question continues on the following page)

(Question B1, part 2 continued)

(iii) Define *binding energy* of a nucleus. *[1]*

Minimum Energy required to seperate the nucleons in the nucleus

(iv) The following data are available.

Nuclide	Binding energy per nucleon / MeV
americium-241	7.54
neptunium-237	7.58
helium-4	7.07

Determine the energy released in the reaction in (b). *[3]*

Am-241 $241 \times 7.54 = 1817.14$ MeV

Np-237 $237 \times 7.58 = 1796.46$ MeV
He-4 $4 \times 7.07 = 28.28$ MeV
} 1824.74 MeV

$1824.74 - 1817.14 = 7.60$ MeV
MeV MeV