Energy Science (XE-I) Sample Question Paper. Answers are given in bold.

Q.176 – Q.184 Carry ONE mark Each

Q.176	Which of the following does not consider the time value of money?
(A)	**Simple payback period**
(B)	Discounted payback period
(C)	Net present value
(D)	Levelized cost of energy
Q.177	Which of the following is not a greenhouse gas?
(A)	Methane (CH_4)
(B)	Carbon dioxide (CO_2)
(C)	**Hydrogen (H_2)**
(D)	Nitrous oxide (N_2O)

Q.178	In a coal-fired boiler, the hourly consumption of coal is 1000 kg. The ash content in the coal is 3 %. What is the amount of ash formed per day if the boiler operates 24 hours per day?
(A)	50 kg
(B)	300 kg
(C)	33 kg
(D)	**720 kg**
Q.179	According to a recent report, the R/P ratio for coal for the year 2024 is 134. The unit of this ratio is ____.
(A)	Tonnes
(B)	**Years**
(C)	Tonnes per year
(D)	MJ per tonne

Q.180	The input current drawn by a 3-phase induction motor rated at 400 V, 10 kW is 20 A at 0.80 power factor. The efficiency of the motor is around ____.
(A)	84 %
(B)	**90 %**
(C)	93 %
(D)	87 %
Q.181	Which of the following is a concentrating solar thermal collector?
(A)	Flat plate collector
(B)	Photovoltaic module
(C)	**Parabolic trough collector**
(D)	Solar pond

Q.182	Given that the mass of a neutron is 1.00866 amu and the mass of ^{13}C is 13.00335, then the binding energy of the last neutron of ^{13}C is approximately ____.
(A)	1 MeV
(B)	10 MeV
(C)	**5 MeV**
(D)	100 MeV
Q.183	A pumped hydro storage system is designed to pump water to a reservoir located at a height of 150 m. If 2000 m^3 of water has been pumped up and the system's water to electricity conversion efficiency is 85 %, then the electrical energy that can be recovered from the storage is **2.5** GJ. (Round the answer to one decimal place) Assume the dynamic viscosity of water to be 0.0009 Pa s, thermal conductivity to be 0.6 W/(m K), specific heat to be 4.2 kJ/(kg K), and density to be 1000 kg/m^3. Assume acceleration due to gravity to be 9.8 m/s^2.
Q.184	An oil-fired boiler produces 1000 kg/h of steam, with an increase in the specific enthalpy of steam equal to 2500 kJ/kg during the process. The calorific value of the fuel oil is 40 MJ/kg, and its consumption is 100 kg/h. The boiler efficiency is **62.5** %. (Round the answer to one decimal place)

Q.185 – Q.197 Carry TWO marks Each

<table>
<tr><td>Q.185</td><td>In the context of solar radiation and sun-earth geometry, “solar constant” is:</td></tr>
<tr><td></td><td></td></tr>
<tr><td>(A)</td><td>Solar radiation intensity just outside the earth's atmosphere</td></tr>
<tr><td>(B)</td><td>Average distance between sun and earth</td></tr>
<tr><td>(C)</td><td>Solar radiation intensity at earth's surface</td></tr>
<tr><td>(D)</td><td>Angle made by the extreme most sunrays at earth's centre</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Q.186</td><td>A 3-bladed horizontal-axis wind turbine of 100 kW rated capacity and a blade length of 12 m, operates with a cut-in wind speed of 2 m/s and a cut-out wind speed of 15 m/s. The ambient air has a density of 1.2 kg/m^3. The turbine operates with 40 % efficiency, and is installed at a location with the following wind profile for 9 hours of a day:
<table>
<tr><td>Hours of the day</td><td>1,2,3</td><td>4,5,6</td><td>7,8,9</td></tr>
<tr><td>Wind speed (m/s)</td><td>1.4</td><td>3.2</td><td>4.1</td></tr>
</table>
The energy generated by the wind turbine in these 9 hours is around ____.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>(A)</td><td>35356 Wh</td></tr>
<tr><td>(B)</td><td>33122 Wh</td></tr>
<tr><td>(C)</td><td>88391 Wh</td></tr>
<tr><td>(D)</td><td>82805 Wh</td></tr>
<tr><td></td><td></td></tr>
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Q.187	A manufacturing facility has two 10 MW power-generating units – one using natural gas as the fuel and one using coal as the fuel. The company also has a large office building, which is heated using a diesel-fired space heating system. Last year, the company consumed 18 million m^3 of natural gas and 15000 tonnes of coal in the power generating units. It also began last year with 49800 L of diesel in storage and ended the year with 14300 L in storage; it burned the rest of the diesel. Assuming the emission factor for natural gas to be 1.914 $kgCO_2/m^3$, for coal to be 2274.7 $kgCO_2$/tonne, and for diesel to be 2.653 $kgCO_2$/L, the company's total emissions of carbon dioxide (CO_2) for last year would be approximately ____.
(A)	137334 tonnes of CO_2
(B)	171032 tonnes of CO_2
(C)	**68667 tonnes of CO_2**
(D)	68705 tonnes of CO_2
Q.188	During the energy audit of a factory, the factory was found to have the following loads connected to a 400 V, 50 Hz power source: i. 20 kVA at a lagging power factor of 0.8 ii. 30 kVA at a leading power factor of 0.9 The value of capacitance required to be installed to correct the power factor to unity is approximately ____.
(A)	43 µF
(B)	**21.5 µF**
(C)	12.3 µF
(D)	6.7 µF

Q.189	A 75 W incandescent bulb provides the same amount of light as that of a 12 W fluorescent lamp. The incandescent bulb costs Rs. 80 and lasts for 800 hours, while the fluorescent lamp costs Rs. 200 and lasts for 8000 hours. If the cost of electricity is Rs. 10 per kWh, then the cost savings due to using the fluorescent lamp instead of the incandescent bulb, for 8000 hours of operation, is Rs. ____.
(A)	240
(B)	**5640**
(C)	4920
(D)	5040600
Q.190	The specific speed N_s of a hydro turbine, with N as the turbine rotational speed, P is the power output from the turbine, and H as the head, is typically expressed by which of the following relations?
(A)	$N_s = \frac{P\sqrt{N}}{H^{\frac{3}{2}}}$
(B)	$N_s = \frac{N\sqrt{P}}{H^{\frac{3}{2}}}$
(C)	$\boldsymbol{N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}}}$
(D)	$N_s = \frac{P\sqrt{N}}{H^{\frac{5}{4}}}$

Q.191	A thermal energy storage system uses a phase change material (PCM) as the storage material placed inside a tank. The storage tank contains 5000 kg of the PCM having specific heat equal to 2 kJ/(kg K) and latent heat of fusion equal to 200 kJ/kg. Using the heat received from a solar thermal collector, the PCM is first heated from 25 °C to 50 °C (PCM's melting point), and then all the PCM is melted. What is the stored thermal energy in the tank after all the PCM is melted?
(A)	**1250 MJ**
(B)	625 MJ
(C)	2500 MJ
(D)	5000 MJ
Q.192	Which among the following is/are included in the Standard Test Conditions (STC) for solar PV modules? (Mark all the correct answers)
(A)	**Solar irradiance of 1 kW/m^2**
(B)	**Air mass of 1.5**
(C)	Wind speed of 1 m/s
(D)	**Solar PV cell temperature of 25 °C**

Q.193	The calculation of net present value (NPV) includes: (Mark all correct answers)
(A)	**Cash flows during the entire life of the project**
(B)	Cash flows until the payback period only
(C)	**Discounting of cash flows**
(D)	Cash flows excluding the O&M costs
Q.194	Biomass can be converted into useful forms of energy through: (Mark all correct answers)
(A)	**Combustion route**
(B)	**Gasification route**
(C)	Crystallisation route
(D)	Velocity route
Q.195	A remote facility consumes 150 kWh of electricity per day. It uses a lithium-ion battery system operating with a nominal voltage of 400 V. The battery system has a usable depth of discharge (DoD) of 85 % and a round-trip efficiency of 90 %. For a backup energy capacity of 3 days, the minimum required battery system capacity is **588** kWh. (Round the answer to the nearest integer)

Q.196	An Energy Manager in a manufacturing company recorded the following information: Energy use in the reference year (2023) was 12 million kJ; Production factor for the current year (2024) is 0.9; and Energy use in the current year (2024) in 11 million kJ. The plant energy performance (PEP) for the company for the year 2024 is **-1.85** %. (Round the answer to two decimal places)
Q.197	A solar photovoltaic (PV) system, containing a certain number of PV modules, is used to power a motor which requires 877 W of power input. Each PV module has 36 multi-crystalline silicon cells, arranged in a 9 × 4 matrix. Each cell is 125 mm × 125 mm and has an efficiency of 12 %. For an incident solar irradiance of 1000 W/m^2 on the plane of the PV modules, the number of modules required to operate the motor is **13**. (Round up the answer to the nearest integer)