DISCUSSION

Discuss some benefits of radiation

After discussing, pick up any energy consumption prize.

DISCUSSION

In the 1950's, the AEC (Atomic Energy Commission) called nuclear pawer "inexpensive, inexhaustible, and safe." Comment on whether of not you agree with this statement.

After discussing, pick up any energy consumption prize.

DISCUSSION

Discuss the pros and cons for funding fusion research.

After discussing, pick up any energy consumption prize.

DISCUSSION

What is "Murphy's Law" and how might it apply to the topic you are currently studying?

After discussing, pick up any energy consumption prize.

DISCUSSION

On 1/1/94, the NRC (Nuclear Regulatory Commission) set a maximum exposure of 5 rems/yr for total body dose of adults working with nuclear materials. If you lived near a nuclear power plant, what kind of information would you want to know?

After discussing, pick up any energy consumption prize.

DISCUSSION

It has been said that "an individual has a much greater chance of dying in an automobile accident than from exposure to fallout from a reactor accident; should we ban all cars if we stop building reactors? Comment on this statement.

After discussing, pick up any energy consumption prize.

FUSION

Your research team makes a major breakthrough in the re-design of the tokomak fusion "donut."

Give each player a 1 kg D-T energy prize.

FUSION

You just got a major grant to work on the Princeton Plasma Physics Laboratory.

Take no energy credits (yet!)

FISSION

10% of the volume of radioactive waste is high-level. To pay for disposal, take no energy prizes.

FISSION

You've developed a way to recycle radioactive waste by reporcessing it. Good for you!

Take 2 energy prizes.

FISSION

Your town uses excess heat from fission to heat homes, help fish breeding, extend plant season, and help waste treatment.

Take 1 energy prize.

FUSION

You're in luck! though He3 is rare on Earth, Moon rocks contain lots of it. Hou used it to successfully fuel a D-HE3 reaction, producing the approximate equivalent of 50 kg of D-T

FISSION

You've just burned 1 kg of U-235. Select an energy prize

FISSION

You've just burned 1 kg of U-235. Select an energy prize

FISSION

1 billion gallons of water are needed per day to dissipate heat associated with nuclear power. Lakes and cooling towers also help. Take 1 energy prize.

FISSION

In 1991, about 55% of our electric generation still cam from coal; 22% from nuclear. Pick another fission card.

FISSION

The useful life of a nuclear power plant is 30–40 years. Due to the shut-down cost, do not pick up an energy prize.

FISSION

Your nuclear plant project will cost $2 billion. Since it will take a long time to get any cash flow, do not pick an energy prize.

FISSION

The cooling tower, with a hyperboloid shape, is not the reactor but functions in exchanging heat. Take another fission card.

FISSION

The thermal efficiency of a nuclear power plant is only about 33%. Give back 1 energy prize.

FISSION

It is March, 1979; Three Mile Island, PA. One of your reactors failed. Return your largest energy prize!

FISSION

Read this to the other players. First person to answer correctly gets an energy prize. What commission oversees the operation of nuclear power plants? (ans: NRC)

FISSION

Thermal pollution occurs in the water near a nuclear power plant (water heats up several degrees). Take no energy prizes.

FISSION

You've just burned 100 kg of U-235. Select an energy prize.

FUSION

You've just burned 1 kg of D-T. Select an energy prize

FUSION

You've just burned 50 kg of D-T. Select an energy prize

FUSION

You've just burned 100 kg of D-T. Select an energy prize

FUSION

Sorry! The plasma needed for the reaction never produced a fusion reaction. Do not take an energy proze.

FUSION

The three basic fusion reactions are deuterium-deuterium, deuterium-tritium, and deuterium-He. Take an energy prize.

FUSION

It's the year 2004, and your JET (Joint European Torus) project in England works! You produced the equivalent of 1 kg of a D-T fuel reaction. Take a 1 kg D-T energy proze.

FUSION

Your fusion funding has not been extended. Take no energy prizes.

FUSION

You figure out a brand new way to confine the plasma needed in a fusion reactor. Your nobel Prize funds the purchase of 3 energy prizes!

FUSION

Your fusion reaction produces, on average, twice as much energy as a fission reaction. Take 2 energy prizes.

FUSION

Your inertial confinement fusion reactor's laser beam got jolted in the last earthquake, throwing it 0.9 cm offline. Give back one fusion energy prize to pay for realignment.

FUSION

Read this to the other plyers. First person to answer correctly gets an energy prize. What does the acronym "laser" stand for? (ans: light amplification by stimulated emission of radiation)

FUSION

Your laser, focused on the D-T fuel provides enough heat to produce fusion. Since you haven't figured out how to do this with a large amount of D-T, take no energy prizes.

NEUTRON

When Uranium decays, radon forms. The buildup of radon gas in homes is thought to be the second leading contributor to lung cancer. (smoking is #1)

FISSION - reactants

NEUTRON

Radioactive "tracers" are radioactive isotopes (varieties of elements with different numbers of neutrons) which are used in experimentation or in medical diagnosis. Examples are: (a)P-32 is put in fertilizer to see how & where P is used by plants. (b) Na24 is injected into the blood to analyze circulation

FISSION - reactants

NEUTRON

For each neutron absorbed in a fuel such as U-235, more than two neutrons (on average) are released.

FISSION - reactants

NEUTRON

There is much evidence that a natural chain reaction probably occurred first in the African state of Gabon about 2 billion years ago. This beats Enrico Fermi (1942) by about 2 billion years

FISSION - reactants

NEUTRON

On 4/26/86, the Chermobyl nuclear fission plant had a major accident. 31 people died due to radioactive fallout.

FISSION - reactants

NEUTRON

The average nuclear power plant uses 1.3 g of U-235 per megawatt-day while producing 300 MW per day. Therefore, about 1.42x10^5 g of U-235 are used per year per reactor.

FISSION - reactants

NEUTRON

Only about 0.1% of uranium ore is U.

FISSION - reactants

NEUTRON

"Light water," or water made with protium (H-1), is used as both a moderator and a coolant in many reactors. Moderators absorb neutrons thus slowing down the nuclear reaction.

FISSION - reactants

NEUTRON

Natural uranium is only about 0.7% uranium, slightly enriched uranium is about 3%, and highly enriched is about 90% uranium. The uranium is usually in the form of UO2 (uranium oxide or UC (uranium carbide)

FISSION - reactants

NEUTRON

If losses of neutrons can be reduced enough, the possibility existst for new fuel to be generated in quantities as large or even larger than the amount consumed. This is called "breeding" and is the process done in a "Breeder reactor."

FISSION - reactants

NEUTRON

Neutrons coming off a fission reaction cannot sustain a nuclear reaction unless there is a critical mass, or minimum amount. This critical mass is approximately 50 kg.

FISSION - reactants

NEUTRON

Morocco and Russion lead the world in uranium reserves. Make sure your country keeps a friendly relationship with these countries!

FISSION - reactants

Deuterium and Tritium

Lawrence Livermore National Laboratories (CA) operates Nova, the world's largest laswer, which produces a beam of light that splits deuterium fuel.

FUSION - reactants

Deuterium and Tritium

A proton and a neutron together make deuterium

FUSION - reactants

Deuterium and Tritium

"Tokamak" is an acronym in Russian for toroid-chamber-magnet-coiol. It is a donut-shaped coil that can both heat up and suspend plasma necessary to the fusion reaction to occur.

FUSION - reactants

Deuterium and Tritium

Tritium can be generated by neutron absorption in lithium.

FUSION - reactants

Deuterium and Tritium

There are 3 isotopes of hydrogen. They are: Protium, which is H-1; Deuterium, which is H-2; and Tritium, which is H-3

FUSION - reactants

Deuterium and Tritium

Two out of every 3500-4500 water molecules contain deuterium.

FUSION - reactants

HEAT!!!

A fusion reaction is also called a thermonuclear reaction since high temps are needed before the "fuel" can overcome the forces which normally keep the particles apart.

FUSION - reactants

HEAT!!!

Since heat is needed to start a fusion reaction, the concept of "cold fusion" has been widely thought of by the scientific community to be a hoax.

FUSION - reactants

HEAT!!!

It takes 100 million degree temperatures to start a fusion reaction; so hot that a magnetic field must contain the reactants.

FUSION - reactants

HEAT!!!

"D-T" is the abbreviation for the fusion fuels called "Deuterium" and "Tritium."

FUSION - reactants

HEAT!!!

A small part of the heat needed in the fusion reactors would be needed to generate tritium by keeping Li_2BeF_4 (flibe) molten.

FUSION - reactants

HEAT!!!

The hydrogen bomb was the first application of fusion energy.

FUSION - reactants

HELIUM+ENERGY+NEUTRON

Fusion scientistst believe they will have fusion reactors in use by early in the 21st century if they are permitted to continue research at the current levels.

FUSION - reactants

HELIUM+ENERGY+NEUTRON

To make the fusion reaction viable, energy output must exceed energy input.

FUSION - reactants

HELIUM+ENERGY+NEUTRON

If you have the correct combination of fuel and heat, you might have achieved fusion, the type of reaction which occurs in the Sun. For every gram of "D-T" fuel used, you just saved the Earth 2400 gallons of oil!

FUSION - reactants

HELIUM+ENERGY+NEUTRON

Thermonuclear or fusion scientists are also known as "plasma physicists."

FUSION - reactants

HELIUM+ENERGY+NEUTRON

The neutron produced in a "D-T" reaction is a disadvantage, since the containment structure becomes slightly radioactive from neutron capture.

FUSION - reactants

HELIUM+ENERGY+NEUTRON

The "D-T" reactor is mostlikely to be the first fusion reactor to be developed.

FUSION - reactants

WASTE+ENERGY+NEUTRON

The two main initial "waste" atoms are Krypton and Barium, which undergo further decay in what is known as a "decay series." Uranium eventually decays to Lead.

FISSION- products

WASTE+ENERGY+NEUTRON

The first nuclear reaction was harnessed on an abandoned squash court at the University of Chicago on 12/2/42.

FISSION- products

WASTE+ENERGY+NEUTRON

Plutonium-240, 241, and 242 are formed in small amounts due to the fission of slightly enriched U-235. These isotopes of Pu are called "transuranic" materials, or actinides, and are used as fuels, poisons, and nucleaqr wastes.

FISSION- products

WASTE+ENERGY+NEUTRON

Cell damage is done when strong enough radiation, known as "ionizing radiation," makes ions out of parts of molecules which destroy the proper genetic information that the cello needs in order to thrive.

FISSION- products

WASTE+ENERGY+NEUTRON

The average person receives over 2000x more radiation from natural sources then from nuclear power.

FISSION- products

WASTE+ENERGY+NEUTRON

In many part of the world, a certain amount of readiation exposure is still thought to be healthy. For example, manhy spas in Europe and elsewhere feature caves and springs where radioactivity is known to be high. People claim better health from being exposed to these small amounts of radioactivity.

FISSION- products

			Energy Prize-Fission			*Energy Prize-Fusion*		
Consumption	**Energy Use**	**Energy Use in Joules**	**Per 1 kg of U-235**	**Per 50 kg of U-235**	**Per 100 kg of U-235**	**Per 1 kg of D-T**	**Per 50 kg of D-T**	**Per 100 kg of D-T**
18 W Fluorescent Lamp (lifetime)	570 kWh	$2.05\ (10)^{9}$ joules	40,000 bulbs	2 million bulbs	4 million bulbs	166,000 bulbs	8.2 million bulbs	16.2 million bulbs
150 lb person walking 1 hr	318,000 calories	1.33 million joules	61.6 million people	3.08 billion people	6.16 billion people	256 million people	1.3 billion people	25.6 billion people
150 lb person snow shoveling 1 hour	1.055 million calories	$4.4\ (10)^{6}$ joules	18.6 million people	930 million people	1.86 billion people	77 million people	3.9 billion people	7.7 billion people
Oiltanker with 3 million barrels of oil		$1.85\ (10)^{13}$ joules	4.4 tankers	220 tankers	440 tankers	18 tankers	919 tankers	1837 tankers
Consumption of energy of US in 1 year	65 quads	$6.86\ (10)^{19}$ joules	$1.2\ (10)^{-6}$ of energy consumption	$6\ (10)^{-5}$ of energy consumption	$1.2\ (10)^{-4}$ of energy consumption	$5.0\ (10)^{-6}$ of energy consumption	$2.5\ (10)^{-4}$ of energy consumption	$5.0\ (10)^{-4}$ of energy consumption
Space heating of homes in US for 1 year	4.55 quads	$4.8\ (10)^{18}$ joules	$1.7\ (10)^{-5}$ of heat for homes	$8.5\ (10)^{-4}$ of heat for homes	.0017 of heat for homes	$7.08\ (10)^{-5}$ of heat for homes	.0035 of heat for homes	.007 of heat for homes
U.S. autos for 1 year	10.5 quads	$1.1\ (10)^{19}$ joules	$7.4\ (10)^{-6}$ of energy for autos	$3.7\ (10)^{-4}$ of energy for autos	$7.4\ (10)^{-4}$ of energy for autos	$3.1\ (10)^{-5}$ of energy for autos	.0015 of energy for autos	.003 of energy for autos
Wasted process steam in US for 1 yr	8.4 quads	$8.63\ (10)^{18}$ joules	$9.5\ (10)^{-6}$ of energy from waste	$4.8\ (10)^{-4}$ of energy from waste	$9.5\ (10)^{-4}$ of energy from waste	$4.0\ (10)^{-4}$ of energy from waste	.002 of energy from waste	.004 of energy from waste
Energy consumption from coal in US	16.1 quads (for 1 yr)	$1.7\ (10)^{19}$ joules	$4.8\ (10)^{-6}$ of energy from coal	$2.4\ (10)^{-4}$ of energy from coal	$4.8\ (10)^{-4}$ of energy from coal	$2\ (10)^{-5}$ of energy from coal	.001 of energy from coal	.002 of energy from coal
Energy consumption from oil in US	28.7 quads (for 1 yr)	$3.03\ (10)^{19}$ joules	$2.7\ (10)^{-6}$ of energy from oil	$1.35\ (10)^{-4}$ of energy from oil	$2.7\ (10)^{-4}$ of energy from oil	$1.1\ (10)^{-5}$ of energy from oil	$5.6\ (10)^{-4}$ of energy from oil	.0012 of energy from oil