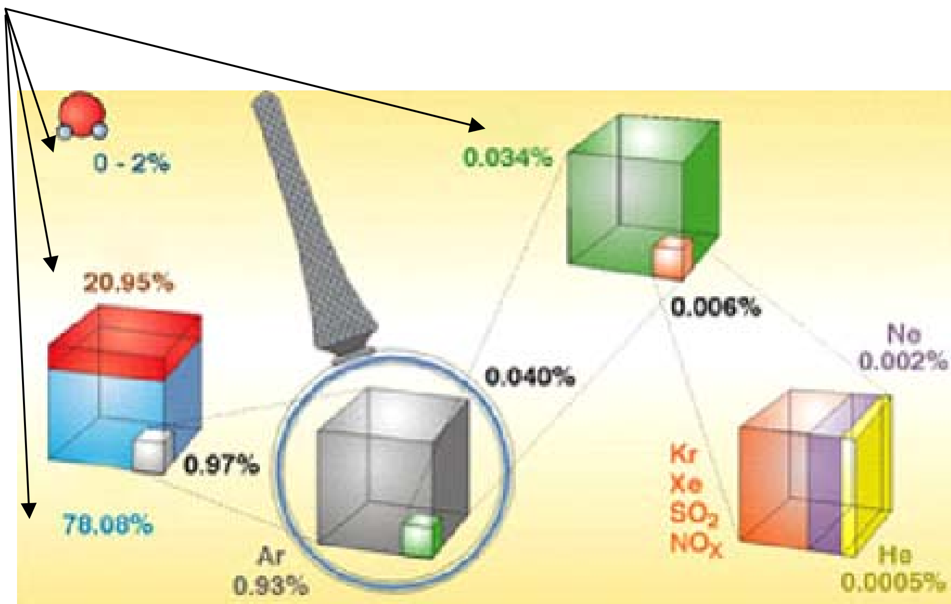
TEST 3 (of 3)

Show all of your work. Students should make use of the conversion factor method throughout and express their answers in scientific notation.

1. **Global warming**

(a) Add the names of the 4 missing gases to the diagram below. Which of these 4 are infra-red active?



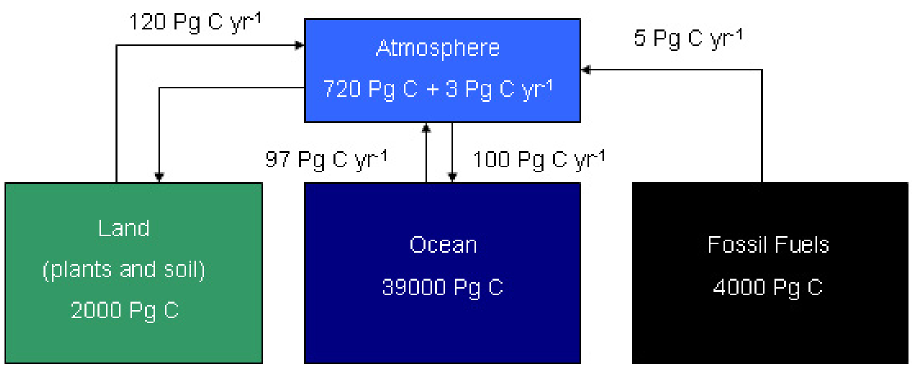
(b) There is much more water vapor in the atmosphere than carbon dioxide, why isn't water vapor considered a problem when discussing the man-made enhanced greenhouse effect?

(c) Based solely on changes in radiation fluxes, are the following events expected to have an overall cooling or warming effect on climate?

- increased desertification
- loss of polar ice caps
- emission of aerosols/particulates from industry
- urbanization (building more roads etc.)

2. **Radiative forcing**

(a) Which environmental compartment is the largest active sink for carbon dioxide gas? How many more times does this sink store carbon than the other compartments?



(b) A suggested model of the changes in radiative forcing (ΔF) due to fluctuations in atmospheric carbon dioxide gas concentrations (C) is:

$$\Delta F = 6.3 \ln (C/C_0)$$

(i) What is the effect of doubling the atmospheric CO_2 concentration from 350 ppm to 700 ppm on the outward flux of energy (W m^{-2}) from the earth?

(ii) If F_{in} = 240 W m^{-2} calculate the new F_{out} using the following equation:

$$\Delta F = F_{in} - F_{out}$$

(c) Earth's surface temperature has been shown to increase linearly with changes in ΔF. Write down an equation relating temperature (T) to ΔF . Calculate the rise in temperature assuming a constant rate of increase 0.30 K / W m^{-2}.

3. **Fission**

(a) Complete the following nuclear reactions for the fission of uranium-235.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{37}\_\_\_\_\_ + ^{143}_{55}\_\_\_\_\_ + 3\, ^{1}_{0}n$$

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{148}_{57}\_\_\_\_\_ + ^{85}_{35}\_\_\_\_\_ + 3\, ^{1}_{0}n$$

(b) The following questions relate to the nuclear fission reaction:

$$^{235}U + ^{1}_{0}n \rightarrow ^{142}Ba + ^{91}Kr + 3\, ^{1}_{0}n$$

Data:

The atomic masses of ^{235}U, ^{142}Ba, ^{91}Kr, and $^{1}_{0}n$ are 235.044, 141.926, 91.923, and 1.008665 amu respectively.

$E = \Delta mc^2$ where $c = 2.99792 \times 10^8$ ms^{-2}, 1 J = 1 kg m^2 s^{-2}.

(i) Calculate the change in mass Δm.

(ii) Calculate the amount of energy released in joules from the fission of 235.044 g uranium-235.

(c) Calculate the maximum percentage efficiency (η) in converting heat, according to the second law of thermodynamics. Use the equation below,

$$\eta = \frac{T_{hot} - T_{cold}}{T_{hot}}$$

(i) At the core temperature of a nuclear reactor (300 ºC) into electricity assuming that the cooling water is at 17 ºC.

(ii) Repeat the calculation for a fossil fuel plant (550 ºC).

[Answer: 48 and 60 %]

4. **Nuclear Accidents**

(a) The rate of radioactive decay is proportional to amount remaining after time *t*.

$$N = N_0 e^{-\lambda t}$$

Where N = number nuclei at time t, N_0 = number of nuclei at start, λ = decay constant.

Derive the expression for half-life which occurs when $N = N_0/2$.

[Answer: $\lambda = \ln 2 / t_{1/2}$]

(b) Thyroid cancer rates around the 30 km exclusion zone increased presumably by irradiation from beta radiation decay of radioactive Iodine-131 ($t_{1/2}$ = 8 days). Write down the radioactive decay equation for this radioisotope.

(c) Tablets of potassium iodide were distributed to people living around Chernobyl a week after the nuclear accident, to protect against accumulation of the radioactive ^{131}I isotope.

(i) What percentage of the ^{131}I (N/N_0 , where $N/N_0 = e^{-\lambda t}$) released by the explosion would have remained by that time?

(ii) How long would it have taken for 99% of the releases ^{131}I to undergo radioactive decay?

5. **Radon**

(a) Complete the following radioactive decay reactions for radon and its progeny.

$^{222}_{86}Rn \rightarrow {}^{218}_{84}Po +$ ____ ($t_{1/2}$ = 3.8 days)

$^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi +$ ____ ($t_{1/2}$ = 28.6 min)

$^{214}_{84}Po \rightarrow {}^{210}_{82}Pb +$ ____ ($t_{1/2}$ < 1 s)

Which type of ionizing radiation is the most damaging when emitted from inhaled radionuclides? (give the chemical symbol in the form $^{A}_{Z}X$ where A = atomic mass, Z = atomic number.

(b) A steady-state 1-box model for radon concentration in a room yields the following conditions:

$$S_{Rn} + \frac{q^0_{Rn}}{\tau_v} = \frac{q_{Rn}}{\tau_v} + \frac{q_{Rn}}{\tau_{Rn}}$$

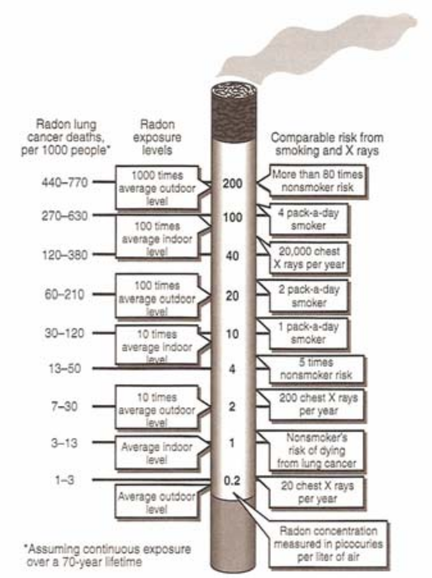
Where S_{Rn} = source of radon, q^0_{Rn} = outdoor air radon concentration = 0.2 pCi L^{-1},
τ_v = residence time of air in the space (ventilation time), q_{Rn} = indoor radon concentration, τ_{Rn} = rate of radon decay (half-life).

Solve for q_{Rn}, the indoor radon concentration.

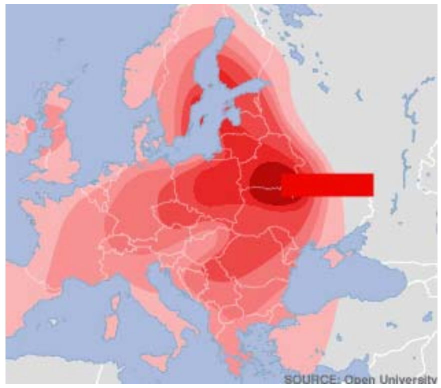
(c) A criminal is sentenced to life imprisonment in a small cell. The cell has an average radon source of 10 pCi L^{-1} hr^{-1}. The air in the cell is exchanged every 4 hours.

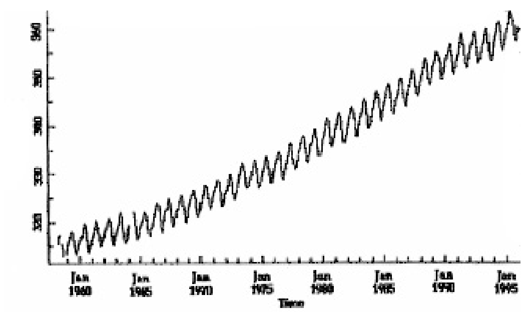
(i) What is the concentration of radon in the cell under steady-state conditions?

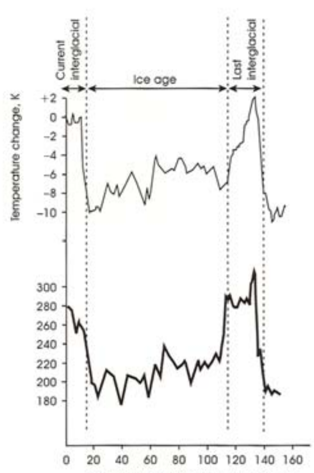
(ii) If the criminal is 20 years old when first incarcerated, confirm that the probability that he will contract lung cancer by the time he is 90 years old (assuming that no other specific risks for lung cancer exist) is 12-38 %.



Bonus: Identify the subject area of each of the following 4 diagrams and describe what they show.







Periodic Table of Elements

Representative elements

Alkali metals | Alkaline earth metals | Halogens | Noble gases

Transition elements

Period number	1 Group 1A	2 Group 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Group 3A	14 Group 4A	15 Group 5A	16 Group 6A	17 Group 7A	18 Group 8A
1	1 H 1.008																	2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	57* La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209	85 At 210	86 Rn 222
7	87 Fr 223	88 Ra 226	89† Ac 227	104 Rf 261	105 Db 262	106 Sg 263	107 Bh 262	108 Hs 265	109 Mt 266	110 — 269	111 — 272	112 — 277		114 — 289				

*Lanthanides	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 145	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
†Actinides	90 Th 232.0	91 Pa 231	92 U 238.0	93 Np 237	94 Pu 244	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 260

Metals | Metalloids | Nonmetals