AP® Chemistry
2003 Sample Student Responses
Form B

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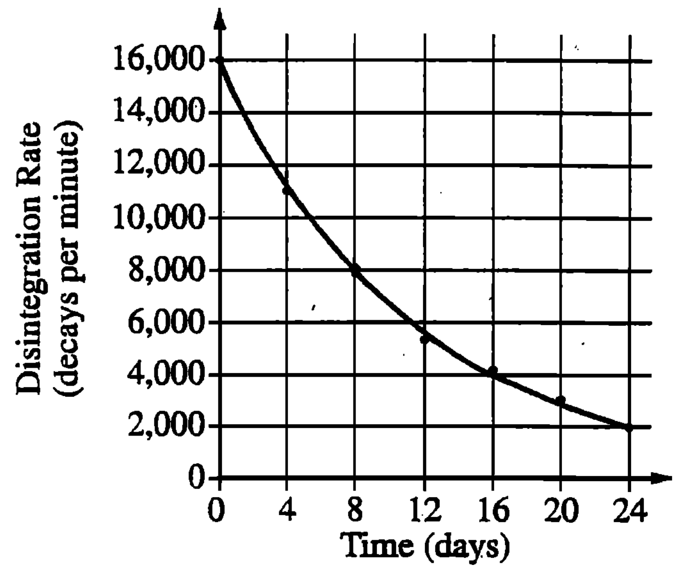
8A1

8. The decay of the radioisotope I-131 was studied in a laboratory. I-131 is known to decay by beta ($_{-1}^{0}e$) emission.

(a) Write a balanced nuclear equation for the decay of I-131.

(b) What is the source of the beta particle emitted from the nucleus?

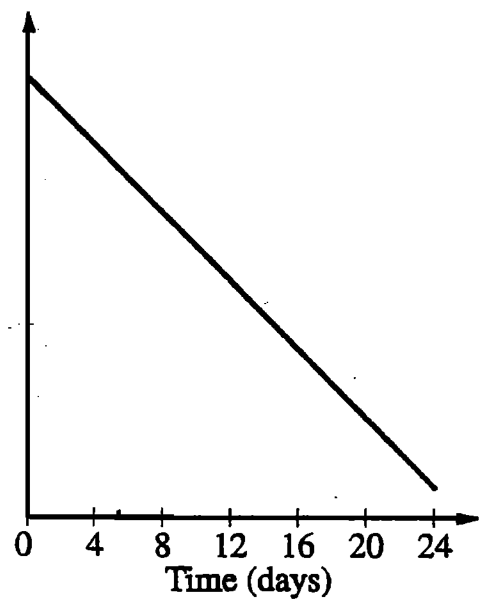
The radioactivity of a sample of I-131 was measured. The data collected are plotted on the graph below.



(c) Determine the half-life, $t_{1/2}$, of I-131 using the graph above.

(d) The data can be used to show that the decay of I-131 is a first-order reaction, as indicated on the graph below.

ln S(amount of substance left)



(i) Label the vertical axis of the graph above.

(ii) What are the units of the rate constant, k, for the decay reaction?

(iii) Explain how the half-life of I-131 can be calculated using the slope of the line plotted on the graph.

(e) Compare the value of the half-life of I-131 at 25°C to its value at 50°C.

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(a) $^{131}_{53}I - ^{0}_{-1}e \longrightarrow ^{131}_{54}Xe$

(b) When a beta particle is emitted a neutron emits an electron and becomes a proton. The neutron is the source.

(c) $t_{1/2}$ → time for half the given sample to decay

$d_{1/2} = 8$ days

(d)(ii) $\ln S = -kt + \ln S_0$

Half-life $= \frac{\ln 2}{k}$

∴ k is in days^{-1}

(iii) The slope of this graph is $-k$. Half-life can be calculated by dividing ln 2 by the negative of the slope.

Half-life $= \frac{\ln 2}{k}$

(e) It is the same. Radioactive decay is not a chemical process and does not depend on temperature. The rate of decay depends on the nature of substance (thermodynamic considerations) and the amount of substance left.

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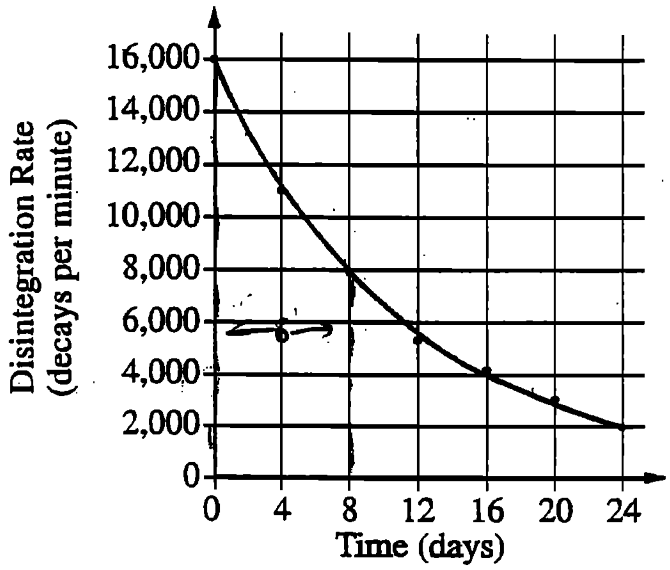

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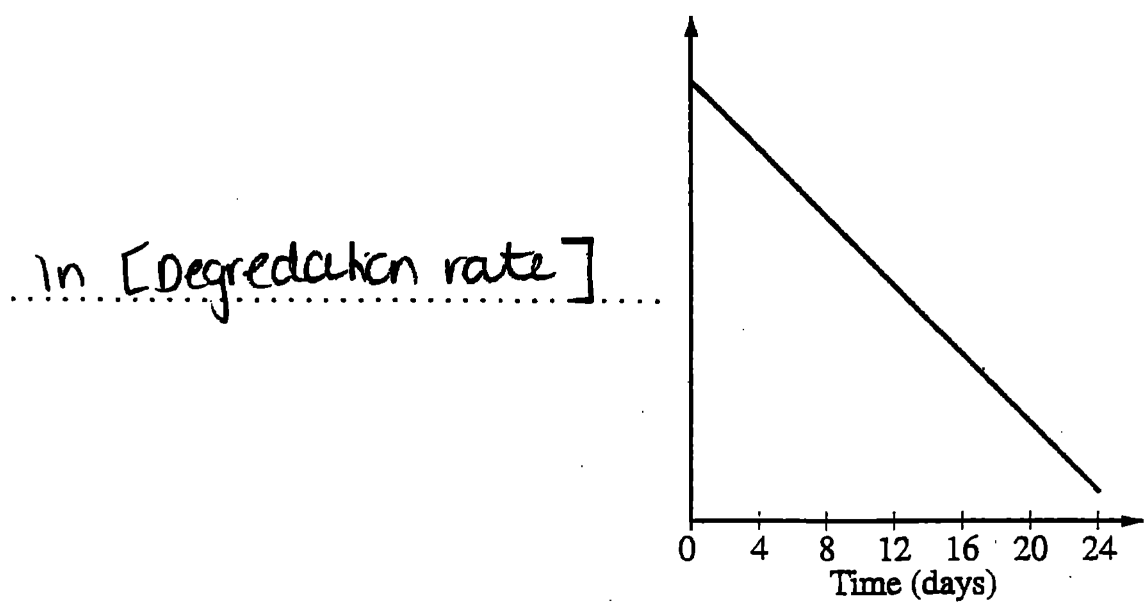

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(a) $^{131}_{53}I \rightarrow ^{0}_{-1}e + ^{131}_{54}Xe$

(b) A neutron in the nucleus of I

(c) 1/2 life ⇒ time required for 1/2 material to decay.
taking time difference from 16000 → 8,000
we find that the half life is 8 days.

d) (i) 1st order ⇒ ln[k] ∝ t
⇒ axis label is ln [Degredation rate]

ii) $\ln[A] = -kt + \ln[A_0]$
⇒ $k = -\text{slope} = -\frac{\text{no units}}{\text{days}}$

⇒ units for k are days^{-1}

iii) 1/2 life ⇒ $[A] = \frac{1}{2}[A_0]$
$\ln\left[\frac{A_0}{2}\right] = -kt_{1/2} + \ln[A_0]$
$\ln\left[\frac{1}{2}\right] = -kt_{1/2}$
$-\ln 2 = -kt_{1/2}$ ⇒ $t_{1/2} = \frac{\ln 2}{k}$

The slope of the graph = −k
⇒ k = −slope
⇒ t½ can be calculated by dividing ln2 with −slope.
i.e. $t_{1/2} = \frac{\ln 2}{-\text{slope}}$

(e) At a higher temperature (ie. 50°C) the components

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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

of the atom would be at a more excited state. Consequently, since systems tend to lower energy, the rate of emission of these particles would increase, i.e. k increases

$$t_{1/2} = \frac{\ln 2}{k}$$

The half-life of a radioactive particle & the rate constant k are inversely proportional. This means that as k increases, $t_{1/2}$ would decrease.

$\therefore$ $t_{1/2}$ at 50°C < $t_{1/2}$ at 25°C

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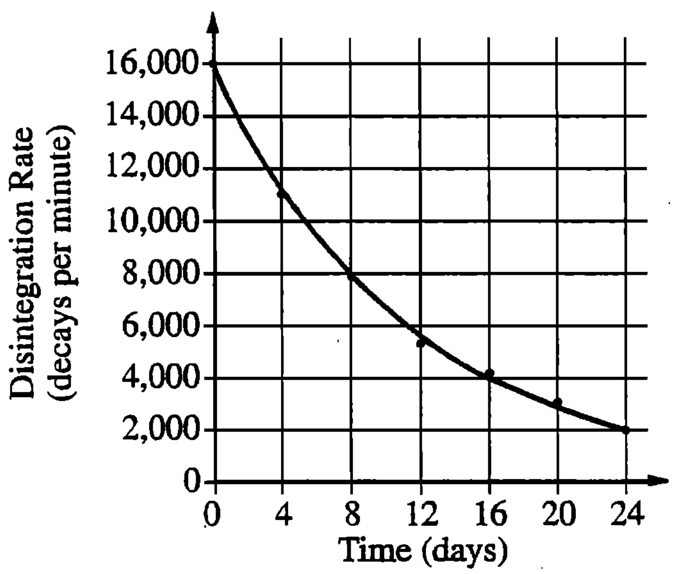

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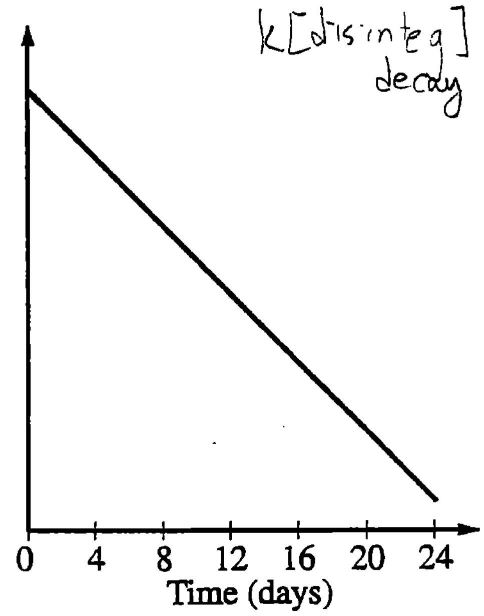
ln (disintegration rate) ....



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ADDITIONAL PAGE FOR ANSWERING QUESTION 8.

(a) $^{131}_{53}I \rightarrow {}^{0}_{-1}e + {}^{131}_{54}Xe$

(b) It is the radioactivity that results in the detatchment of an electron.

(c) The disintegration rate halfs every 8 ~~months~~ days.
∴ $t_{1/2} = 8$ days

(d) (i) <on the diagram>

(ii) $t_{1/2} = \frac{0.693}{k}$ $\quad k = \frac{0.693}{t_{1/2}}$

$k = \frac{0.693}{8 \text{ days}} = 0.0853 \text{ days}^{-1}$ so,

the unit is days^{-1} or (time^{-1})

(iii) the slope of the graph yields the halflife value

(e) The ~~rea~~ halflife value decreases as the rate is faster as the Temperature increases. ~~and~~ There are more collisions hence more vibrant reations.

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