1. The Greeks used philosophy in their investigation of scientific problems. They developed ideas by reasoning and discussion. Experimentation did not occur generally. Modern scientists use the scientific method to investigate scientific problems. This involves, among other things, making a hypothesis and testing it.

2. (a) \[ E = \frac{V}{d} = \frac{210 \text{ V}}{0.006 \text{ m}} = 35000 \text{ V/m} \]

(b) \[ E = \frac{m \cdot a}{L} = \frac{2 \text{ kg} \cdot 10^5 \text{ m/s}^2}{6 \text{ s}^2} = 33333.3 \text{ m/s}^2 \]

(c) \[ E = \frac{m \cdot a}{L} = \frac{1.3 \times 10^{-8} \text{ C} \cdot 5 \text{ s}^{-1}}{1.27 \times 10^{-8} \text{ C}} = 0.4 \text{ s}^{-1} \]

3. The study of science is our attempt to explain the natural events in the universe. The study of radioactivity is real science.

4. The discovery of X-rays led to the discovery of radioactivity. Without the discovery of X-rays, radioactivity would have been discovered, but at a later date.

5. The Curie's used the electrometer (invented by Jacques and Pierre Curie) to study radioactivity (See Fig. 27.9 P 664)

6. Alpha particles are helium ions: \( ^2 \text{He}^2 \)

7. Roentgen's experiments with cathode ray tubes led to the discovery of X-rays. The study of X-rays led to the discovery of radioactivity.

8. The alpha particle is large and relatively slow moving. It is slowed and eventually stopped by collisions with other particles. Its weak positive charge and its large size ionizes other particles by shaking them apart (producing into and neutrinos) or by capturing electrons (producing helium ions).

9. Gold \(^{197}\)Au has a large number of protons in its nucleus. This would have a greater effect on any helium nucleus (alpha particle) in the vicinity.

Rutherford's experiment showed that the mass of the atom was concentrated in a tiny, positively charged nucleus. Most of the atom was space.

10. Not the right answer but still a good summation

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Makeup</th>
<th>Penetrating Ability</th>
<th>Ionizing Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha</td>
<td>2 protons absorbed by</td>
<td>a strong ionizing agent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 neutrons paper</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a He nucleus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>beta</td>
<td>an electron can be</td>
<td>lower than for ( \alpha ) radiation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>absorbed by a few mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>of metal foil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gamma</td>
<td>very short wavelength</td>
<td>penetrates only weakly ionizing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>electromagnetic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 meter of concrete</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. In Thompson's model, the atom is a ball of positive charge with electrons scattered throughout, like a plum pudding. If this model was correct, the alpha particle in Rutherford's experiment would not have scattered so much, since Thompson's atom is neutral (the alpha particle has a charge of +2).

12. \( ^{12}\)C \( ^{14}\)C

13. \( ^{3}\)He \( ^{4}\)He

14. Neutrons have high penetrating ability because they have no charge and do not interact with electrostatic fields around atoms. Being rather heavy particles, the carry considerable kinetic energy. In Joliot-Curie's experiment, protons were physically knocked out of wax by neutrons.

15. (a) \( p = 1, n = 1 \) (b) \( p = 6, n = 6 \) (c) \( p = 0, n = 0 \)

16. In 100 atoms, we have

\[
\begin{align*}
\text{Total} &= 2910.5 \text{ g} \\
\text{Average} &= 28.105 \text{ g} \\
\end{align*}
\]
22. (a) \( ^{35} \text{U} \) has 92 protons and 143 neutrons.

\[ \text{mass of 92 protons} = 1.107 \times 10^{-26} \text{ kg} \]
\[ \text{mass of 143 neutrons} = 1.108 \times 10^{-25} \text{ kg} \]
\[ \text{Total mass} = 2.215 \times 10^{-25} \text{ kg} \]

\[ \text{observed mass} = 238.0289 \text{ MeV} \]
\[ \text{mass defect} = 2.215 \times 10^{-25} \text{ kg} \]
\[ = 138 \text{ MeV/nucleon} \]

(b) \( ^{35} \text{U} \) has 92 protons and 143 neutrons.

\[ \text{mass of 92 protons} = 1.107 \times 10^{-26} \text{ kg} \]
\[ \text{mass of 143 neutrons} = 1.108 \times 10^{-25} \text{ kg} \]
\[ \text{Total mass} = 2.215 \times 10^{-25} \text{ kg} \]

\[ \text{observed mass} = 238.0289 \text{ MeV} \]
\[ \text{mass defect} = 2.215 \times 10^{-25} \text{ kg} \]
\[ = 138 \text{ MeV/nucleon} \]

(22b) and (22c): As above. 0.2% leaves out.

24(a)(i) The filament is heated to give enough energy to escape the metal.

(b) The electrons accelerate because they are repelled by the anode and attracted by the cathode.

25. \[ E = \frac{V}{d} = \frac{1200 \text{ V}}{0.002 \text{ m}} = 6 \times 10^6 \text{ V/m} \]

26. \[ q = \frac{m g}{E} \] (total charge on sphere)

27. Alpha particles with a charge of +2 would be strongly repelled by a heavy nucleus. At the alpha got closer to the nucleus, the force of repulsion would increase greatly since \( E \alpha 1/r^2 \) (1/2 the distance, \( E \alpha 1/r^4 \)) for the above reason A, B and C are incorrect. C is incorrect, for although it correctly shows the closer particle repelled the most, the outer particle seems totally unaffected.

D is the best alternative but I do not like the question because it appears the alpha particle goes past the nucleus before it is strongly repelled.

28. \[ E \dot{q} \] when stationary:

\[ \frac{m g m}{g} = \frac{E q}{g} \]

\[ 0 \text{ when turned on the side:} \]

vector diagram:

\[ \text{X axis in the direction of force on F in Fig. 27.24} \]

\[ \text{mg} \]