New Century Physics for Queensland (3rd ed, 2019) – Oxford University Press.

Practice exam answers for Unit 4

Page 400 - 401 of the Student Book

Explanations for the answers to the multiple choice questions.

By Dr Richard Walding

Q	Ans	Explanations
1	C	The question is a bit ambiguous; I'll grant you that. What I meant by "it's rest length" was the rest length of the spaceship (and not the planet). With that cleared up - Rest length is measured by an observer at rest to the object being measured. So, it has to be measured by someone aboard the spaceship and at rest. They are just using the beam of light to measure the time taken between the front and back of the spaceship, so this is the correct answer.
2	A	The answer is actually A. At slow speeds the two formulas give the same answer for momentum, so the ratio is 1:1. As speed becomes relativistic (> 0.1 c) the relativistic momentum starts to get greater than Newtonian momentum. You can see the red line slowly get further and further away from the 1.0 line of the ratio axis (y-axis). At very high speeds approaching 1.0 c, the redline shoots off towards infinity.
3	B	$\Delta E = \Delta mc^2$ $= \frac{1}{1000} \times (3 \times 10^8)^2$ $= 9 \times 10^{13}\ J$

<table>
<tr>
<td>4</td>
<td>A</td>
<td>
$W = 5.6eV = 5.6 \times 1.6 \times 10^{-19} = 8.96 \times 10^{-19} J$
$\lambda = 200nm = 200 \times 10^{-9} m$
$f = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{200 \times 10^{-9}} = 1.50 \times 10^{15} Hz$
$E_K = hf - W$
$= \frac{6.626 \times 10^{-34} \times 1.50 \times 10^{15}}{1.6 \times 10^{-19}} - 5.6$
$= 6.2 - 5.6$
$= 0.6eV$
Alternatively
$E_K = hf - W$
$= (6.626 \times 10^{-34} \times 1.50 \times 10^{15}) - 8.96 \times 10^{-19}$
$= 9.939 \times 10^{-19} - 8.96 \times 10^{-19}$
$= 0.979 \times 10^{-19} J$
$= \frac{0.979 \times 10^{-19}}{1.6 \times 10^{-19}}$
$= 0.6eV$
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<tr>
<td>5</td>
<td>B</td>
<td>
The photon energies will only cause a transition in the hydrogen atom if it equals the difference in energy between any two levels.
<table>
<tr><th>Possible transition</th><th>Energy required (eV)</th><th>Possible photon/s</th></tr>
<tr><td>-13.6 → -3.4</td><td>10.2</td><td>X</td></tr>
<tr><td>-13.6 → -1.5</td><td>12.1</td><td>Y</td></tr>
<tr><td>-13.6 → -0.9</td><td>12.7</td><td>nil</td></tr>
<tr><td>-3.4 → -1.5</td><td>1.9</td><td>nil</td></tr>
<tr><td>-3.4 → -0.9</td><td>2.5</td><td>nil</td></tr>
<tr><td>-1.5 → -0.9</td><td>0.6</td><td>nil</td></tr>
</table>
Only X and Y could cause a transition.
</td>
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<tr>
<td>6</td>
<td>A</td>
<td>By definition, an antiparticle has the same mass but opposite charge to the corresponding particle. A proton has the mass of a proton and a positive elementary charge (1+). So, an antiproton will have the same mass as a proton but a negative elementary charge (1-) which is the same charge as on an electron.</td>
</tr>
</table>

7	A	"Order of decreasing strength" means to go from the strongest force to the weakest force. This is correct in Option A. You just have to learn this off by heart. There is nothing to work out.
8	D	A meson is made up of a quark (q) and an antiquark ($\bar{q}$). The only one that has this combination is Option D. Option (A) has three quarks, (B) has two antiquarks and is impossible, (C) has two quarks and is also impossible. Remember, the only combinations of quarks are: three quarks (a baryon), or three antiquarks (an antibaryon), or a quark/antiquark pair (a meson). There may be some more exotic combinations (known as 'exotic hadrons' such as a tetraquark) but this is not required for the External Exam.
9	C	A baryon has a baryon number of +1. A baryon has a lepton number of 0 as it is not a lepton. Alternatively, you could use the formula in the syllabus (page 65 & 80) or NCPQ U3&4 (page 374-5) to show that a baryon (3 quarks) has a B = 1 and L = 0 by: $B = \frac{1}{3}(n_q - n_{\bar{q}})$ $= \frac{1}{3}(3-0)$ $= 1$ $L = n_l - n_{\bar{l}}$ $= 0-0$ $= 0$
10	A	On the left there are an electron (e-) and a positron (e+) coming together. They combine to form a photon (γ) shown by the wavy line. The photon then forms a new electron (e-) and another positron (e+). Actually, when the e- and e+ combine they 'annihilate' to form the photon. The photon then decays to form a new e- and a new e+. The photon in the middle is a *virtual* photon, not one of your ordinary photons such as found in light. Look, you just have to learn and draw the four Feynman diagrams and be able to describe the interactions. See NCPQ U3&4 pages 384-386, or the Feynman Diagrams booklet from the QCAA website.