Question 40 (Answer: **B**)

- Leptons are fundamental particles that feel no strong force: electrons, positrons, muons and neutrinos.
- A meson and a proton are both hadrons, built from quarks.
- A quark is fundamental too, but it belongs to its own family, not the leptons.

Question 38 (Answer: **C**)

- An up quark carries $+\frac{2}{3}e$ and a down quark $-\frac{1}{3}e$.
- The change is $-\frac{1}{3}e - (+\frac{2}{3}e) = -1e$.
- So the magnitude is e – which is exactly the charge change in β^+ decay.

Question 40 (Answer: **D**)

- Up, charm and top each carry $+\frac{2}{3}e$; down and strange each carry $-\frac{1}{3}e$.
- D gives $+\frac{2}{3} - \frac{1}{3} - \frac{1}{3} = 0$.
- A comes to $-1e$, B to $+1e$ and C to $+2e$.

6(a)	(a particle that) cannot be divided / subdivided (into smaller particles)
6(b)(i)	any combination of one quark and one antiquark
	up / charm / top **and** antiup / anticharm / antitop **or** down / strange / bottom **and** antidown / antistrange / antibottom
6(b)(ii)	$E_{(K)} = \frac{1}{2} mv^2$
	$2.1 \times 10^{-16} = \frac{1}{2} \times 0.67 \times 1.66 \times 10^{-27} \times v^2$
	$v = 6.1 \times 10^5$ m s^{-1}
6(c)(i)	number of electrons = 88
6(c)(ii)	(number of nucleons = 228 – 5 × 4 = 208) number of protons = 88 – (5 × 2) + 4 = 82
	number of neutrons= 208 – 82 = 126 = 126

Question 38 (Answer: **D**)

- Fundamental means not built from anything smaller: quarks and leptons (electrons, positrons, neutrinos) qualify.
- Baryons, mesons, hadrons, neutrons and protons are all made of quarks, so none of them is fundamental.
- Only D avoids every composite particle.

Question 40 (Answer: **B**)

- A hadron made purely of antiquarks must be an antibaryon – three of them.
- Three identical anti-down (or anti-strange) quarks give $3 \times (+\frac{1}{3}e) = +1e$.
- Three anti-up quarks would give $-2e$, so $+1e$ is the only offered value that can occur.

Question 39 (Answer: **A**)

- A meson is a quark–antiquark pair.
- Three quarks make a baryon, such as a proton or a neutron.
- The pairing is why a meson comes out with a whole-number charge.

Question 40 (Answer: **B**)

- β^+ decay turns a proton into a neutron, so the product has 5 protons and 6 neutrons.
- A proton is uud (2 up, 1 down) and a neutron is udd (1 up, 2 down).
- Up: $5(2) + 6(1) = 16$; down: $5(1) + 6(2) = 17$.

Question 33 (Answer: **C**)

- A free charge carrier must carry a whole-number multiple of $e = 1.60 \times 10^{-19}$ C.
- A is $3e$, and B and D are both $2e$.
- C works out at $1.5e$, which is not a whole multiple, so it cannot occur.

Question 38 (Answer: **D**)

- In β^+ emission a proton becomes a neutron and a positron is released.
- Lepton number has to be conserved, and the positron carries -1.
- So a neutrino, with lepton number $+1$, must be emitted with it.

Question 39 (Answer: **A**)

- A down quark has charge $-\frac{1}{3}e$, so its antiquark carries $+\frac{1}{3}e$.
- A strange quark also has $-\frac{1}{3}e$, so the antistrange is $+\frac{1}{3}e$ as well.
- Down and strange sit in the same charge family, which is why both answers are the same.