DC Electric Motors

Multiple choice answers

Question 1

The field from the magnet is from North to South, i.e. right to left across the page. The current is travelling down the page when it is closest to the north pole of the right hand magnet.
Using your right hand thumb to represent the current, the fingers to represent the field, right to left, then the force is into the page.
When viewed from above, this will be seen as an anti-clockwise rotation.

∴ B (ANS)

Question 2

The speed of rotation of the coil depends on the torque on the coil.
To increase this speed of rotation you need to increase the torque.
This is done by increasing the length of wire in the field, by increasing the number of turns, increasing the area of the coil, this increases the size of the lever arm, and increasing the current in the rotating coil, this increases the force acting (F = nBIL).

∴ B (ANS)

Question 3

DC electromagnets (coils, with a current in them) will not change anything because the poles will stay constant, electromagnets act the same as permanent magnets.

∴ D (ANS)

Question 4

The right hand coil is acting like the north pole of a permanent magnet. The left hand coil is acting like the South end of a magnet. (Make sure that you understand this concept).
So the field from the electromagnets is from the right to the left. Put your fingers of your right hand in this direction. Have the palm facing out of the page, because we want side AB to rotate towards us, so this is the direction of the force acting on it. This means that your thumb must be pointing up, so the current is flowing from B to A.
For the coil to continue to rotate their will need to be some way of reversing this current a half cycle later.

∴ C (ANS)

Question 5 (2012 Q2a, 1m, 70%)

With the field from North to South, the current from J to K, The force on JK will be down.

∴ B (ANS)

Question 6

Reversing one of the magnets will mean that the two poles of the magnets are the same. This will result in a very weak field between the two ends, with the field in the middle being zero.
The motor will no longer rotate.

∴ D (ANS)

Question 7 (2014 Q17a, 2m, 75%)

Use the right hand slap rule. The field is from left to right, the current flows from W to X to Y to Z.
∴ The force on WX is down, and the force on YZ is up.
This will cause the coil to rotate in an anticlockwise direction.

∴ C (ANS)

Question 8

Reversing the poles one of the magnets will mean that the two poles of the magnets are the same. This will result in a very weak field between the two ends, with the field in the middle being zero.
The motor will no longer rotate.

Question 9a

The field is from the North pole to the South pole, ie from left to right. This will be the direction of your fingers. The current (your thumb) needs to go from W to X.
∴ the force on WX is **down.**
The force on ZY will be opposite,

∴ up. (ANS)

This is different to the book.

Question 9b

F = nBIL
 $= 30 \times 45 \times 10^{-3} \times 3.5 \times 0.1\text{m}$
(need to convert 10 cm to 0.1 m, watch the units of mT)

= 0.47 N (ANS)

Question 9c

This is because the wire XY is parallel to the field.

∴ Zero (ANS)

Question 9d

After a quarter cycle, ZY is at the top, the force acting on it is now upwards. This does not produce any rotation, so just before this point, the current stops. Just after a quarter cycle ZY has gone past the top, and to continue the rotation we now want the force to be acting downwards on it (and upwards on WX). To achieve this we need to reverse the direction of the current flowing in ZY, the commutator does this.

Question 10a (2012 Q2b, 2m, 66%)

The force on the current carrying wire is given by

F = nBiL
= 50 x 0.05 x 2.0 x 0.06
= 0.30 N (ANS)

Question 10b

This is an interesting question. If the coil has turned one-quarter of a turn then now the wire KL is not parallel to the field, so there will be a force acting on it. Using the right hand rule this force will be out of the page (towards the commutator). **BUT**, this is assuming that the current is still flowing. When the coil rotates through one-quarter turn, the brushes would not be connected, so the current would not flow. I'm not sure exactly what they would want you to answer here.

Question 11

To turn a loop into a DC motor, you need to change the direction of the current every half cycle. This needs to occur when the loop is in a vertical plane. The role of the connections A and B is to change the current. This is the role of a commutator.

Question 12

The left hand electromagnet produces a 'N' pole, and the right hand electromagnet produces a 'S' pole. The current source to the rotor must go through a split ring commutator so that the direction of the current reverses every half cycle.

This means that if the motor was connected to AC instead, then the direction of the 'poles' would be constantly changing, but this would not have any effect on the performance of the motor because the direction of the current in the rotor changes at the same time. This reversal of the field and reversal of the current would not affect the motor.

Question 13a (2013 Q16a, 2m 60%)

Anticlockwise.
The current is from W to X, therefore the force of side WX is down. The force on side YZ is up. This will cause the loop to rotate anticlockwise.

Question 13b (2013 Q16b, 2m, 75%)

Use F = nBiL
∴ F = 20 x 500 x 10^{-3} x 0.5 x 0.05
∴ F = 0.25 N (ANS)

Question 13c (2013 Q16c, 2m, 55%)

No.
The direction of the force will reverse every half cycle, so the loop will oscillate.

Question 14a (2014 Q17b, 2m, 75%)

Use the right hand slap rule. The field is from left to right, the current flows from W to X to Y to Z.
∴ WX: down, YZ: up.

Use F = nBil,
∴ F = 75 × 0.020 × 2.0 × 0.40
∴ F = 1.2 N (ANS)

Question 14b (2014 Q17c, 2m, 50%)

When the current flows, there will be a force on the current carrying wire. The force on WX is up, the force on YZ is down. This will produce a torque that will cause the coil to rotate.

Question 14c (2014 Q17d, 2m, 80%)

The role of the commutator is to reverse the direction of the current at this point, so that the coil will continue to rotate in the one direction.
∴ from W to X
No current
From X to W
At the vertical point, the brushes are not connected to the coil, as they are touching the insulator in the middle section, therefore there isn't a current.

Question 15 (2015 Q12a, 3m, 73%)

Use F = nBiL
∴ F = 10 × 2.0 × 10^{-3} × 4.0 × 4.0 × 10^{-2}
The current flows from F to E, using the right hand slap rule, field is from left to right, so force is up.
= 3.2 × 10^{-3} N Up (ANS)

Question 16a (2016 Q14a, 1m, 40%)

XY is parallel to the field when it is horizontal. The force is zero when the current in the wire is parallel to the field.

Question 16b (2016 Q14b, 2m, 30%)

When the coil is horizontal the torque will be maximum. The current flows anticlockwise through the coil, so the coil will rotate clockwise when viewed from the commutator.
When the coil is vertical, the torque will be zero.

Question 16c (2016 Q14c, 2m, 45%)

From F = nBil.
Increasing the battery voltage will increase the current through the coil. This will increase the force on the current carrying wires, (increase in i), hence increase the torque and the speed of rotation.
Replacing the single coil with several turns will increase the torque, (increase in n), hence the speed.

$\therefore$ **i, ii (ANS)**

In iii, increasing the resistance will decrease the current therefore this will slow the motor down.
In iv, if only one pole is reversed the field between the two ends will be reduced.

Question 17a (2017 Q3a, 3m, 70%)

Use F = nBiL

To find I, use I = $\frac{V}{R}$,

$\therefore$ I = $\frac{9}{6}$

$\therefore$ I = 1.5 A.

$\therefore$ F = 10 × 0.50 × 1.5 × 0.12

$\therefore$ **F = 0.90 N (ANS)**

From the right hand rule, with the field from left to right, the current from J to K, the force is **down, D**.

Question 17b (2017 Q3b, 2m, 75%)

There is no force on KL as it is parallel to the magnetic field.

$\therefore$ **0 N (ANS)**