Advanced Higher Physics

Electrical Phenomena

Past Paper Questions

Solutions

1. (a) (i) (A) 0 NC^{-1}

(B) 3000 NC^{-1}

(ii) work done per unit positive charge in bringing it from infinity to that point

(iii) 540 - 36 = 504 V

(b) -4.5 x 10^{-19} ; not equal to a whole number of electronic charges

2. (a) 2.3 x $10^{-1\ 8}$ N

(b) (i) strong (nuclear) force

(ii) only acts over a range of 10^{-14} N

(c) 2.7 x 10^{-12} m

3. (a) force per unit positive charge acting at that point

(b) (i) use F = eE and F = ma

(ii) 2.6 x 10^{6} ms^{-1}

(c) (i) 1.1 x 10^{-30} kg

(ii) 9.5 x 10^{-14} J

(d) 2.9 x 10^{-14} m

4. (a) (i) force per unit positive charge acting at a point

(ii) see notes: $E = {}^{V}/_{d}$

(b) (i) no field inside sphere

field lines all meet surface of sphere at right angles

(ii) negative charges at top, positive at bottom

(iii) 0

5. (a) $F = kQ_1Q_2\ r^{-2}$ k = constant

(b) touch R and S together
hold positively charged rod near R
separate R and S whilst rod still in position
remove rod - R negatively charged, S positively charged

(c) (i) Use $F = kQ_1Q_2\ r^{-2}$ where $k = 9 \times 10^9$

(ii) 1700 V (to 2 sig figs)

(iii) X - positive charge on right
Y - negative charge on left

(d) (i) 2.5×10^4 N

(ii) 7.0^0

6. (a) (i) $9.5 \times 10^9\ NC^{-1}$

(ii) towards the negative charge

(b) (i) (A) no field inside cylinder
field lines all meet surface of cylinder at right angles

(B) negative charges at top, positive at bottom

(ii) metal mesh screens central wire, which carries signal, from external electric fields, preventing interference - no electric field inside mesh

7. (a) use $eE = {}^1/_2\ mv^2$

(b) 3.9×10^{-9} s

(c) (i) use $E = {}^V/_d$ and $F = eE$

(ii) 16 mm

(d) (i) constant horizontal velocity combined with an increasing vertical velocity

(ii) no significant force acting on electron (gravity force negligible)

(e) increases - electron takes longer to cross plates so there is more time to be accelerated and vertical displacement increases

8. (a) (i) use $V = {}^{kQ}/_{R}$ where R is sphere radius

(ii) 2.8×10^5 V

(iii) (A) 1.6×10^6 NC $^{-1}$

(B) value of E = 0 from centre to 0.18m; thereafter falls from 1.6×10^6 NC $^{-1}$ to almost 0 by 1.0 m according to inverse square relationship (curve steep at first and increasingly *less* steep approaching zero)

(b) 99000 NC $^{-1}$ vertically upwards from P

9. (a) 4.0×10^{-8} N

(b) use F = mg (1.2×10^{-13} N) and compare with

F = qE (4.0×10^{-8} N) - electric force about 10^5 times larger

(c) 2.3×10^{-3} m or 2.3 mm

(d) 10^7 excess electrons

10. (a) (i) use $V = {}^{kQ}/_{r}$

(ii) 138 V

(b) hold rod close to sphere

keeping rod close, touch sphere momentarily

remove rod - sphkere is now positively charged

(c) it's not a whole number multiple of the basic unit of electric charge

11. (a) (i) see notes

(ii) -2.4×10^5 V

(b) (i) use $F = {}^{kQ_1Q_3}/r^2$

(ii) 2.3 N; vertically upwards from Q_3

12. (a) X -ve; Y +ve

(b) (i) 0.12 g/A

(ii) calculate centroid (350;42); gradients of lines through centroid to opposite points of parallelogram etc;

use $Dm \triangleq m_{ac} - m_{bd} / 2\sqrt{(n-2)}$

±0.012

(c) 0.020 T

13. (a) (i) use any two points on line and gradient formula

(ii) calculate centroid (1.50;2.2); gradients of lines through centroid to opposite points of parallelogram etc;

use $Dm \triangleq m_{ac} - m_{bd} / 2\sqrt{(n-2)}$

$\pm 0.33 \times 10^{-3}\ NA^{-1}$

(iii) 0.033 T

(b) (i) systematic uncertainty present (e.g. ammeter over reading)

(ii) take more readings to increase number of points on graph

14. (a) B vertically *into* page

(b) use $E = V/d$ and $F_E = F_B$ so $qvB = qE$ so $v = V/dB$

(c) (i) force due to magnetic field is constant and always at right angles to ion's velocity so force is centripetal and path a circle

(ii) use $qvB = mv^2/r$

(iii) 0.091 m

(d) (i) velocity independent of mass as shown by formula in part (b)

(ii) mass smaller - radius of path directly proportional to ion mass as in (c)(ii) as v, B and Q all constants

15. (a) (i) 0.0280 T

(ii) %unc in F = 2.9%; %unc in l = 2%; %unc in I = 0.4%

overall % unc in B = 3.5%

abs. unc. in B = 0.0099 T (2 sig figs as it would round to a '1')

(iii) increase number of force readings - this would reduce uncertainty in least precise measurement and hence overall uncertainty would be reduced

(b) (i) current is parallel to field (sin a = 0)

(ii) 8.8×10^{-3} Nm

(iii) torque decreases as vertical distance between line of force and axis of rotation smaller

(or in terms of angle, sin a < 1)

16. (a) 0.06 N

(b) 6.6×10^{-3} Nm

(c) 5.7×10^{-3} Nm (6.6×10^{-3} x sin 60)

(d) the force vector stays at right angles to the radius vector (i.e. at right angles to the coil) so sin a stays as 1 or close to it.

17. (a) use $qvB = mv^2/r$

(b) use $T = pr/v$ and substitute from (a); 'v' cancels out

(c) 3.6×10^{-9} s

18. (a) (i) positive

(ii) 9.6×10^{7} Ckg^{-1}

(iii) proton (divide electronic charge by proton mass)

(b) no force horizontally so steady speed in that direction; centripetal force at right angles to field and component of velocity at right angles to field, causing circular path in plane at right angles to B; combination of tow motions results in a helical path

(c) force to magnetic field of Earth deflects the particles away from the Earth as they meet it at a large angle so they don't reach the atmosphere to cause the aurora

19. (a) (i) use $qV = {}^{1}/_{2}mv^{2}$

(ii) 5.0×10^{-3} m

(iii) 8.75×10^{5} ms^{-1}

(b) 1.16×10^{-13} m

(c) 2.8×10^{8} ms^{-1}

20. (a) sin 69 x field

(b) 2.12×10^{-4} N

(c) 0 N

(d) (i) 0.012 m

(ii) cylindrical centre axis along line of wire

21. (a) increasing current through inductor creates increasing magnetic field that induces a back emf which opposes the rise in current

(b) (i) V = IR: 10 V

(ii) 5.0 As^{-1}

(iii) 0.16 J

(c) magnetic field of inductor collapses rapidly inducing a large e.m.f. across the open switch - energy stored by inductor released as electric potential energy, creating the spark

22. (a) see notes for graph shape: maximum p.d. (at start) = 6.0 V

(b) 0.90 As^{-1} (V = IR for p.d. across R; subtract from 6.0V to get emf across L, then dI/dt = E/L)

23. (a) 12 V (b) 4.0 As^{-1} (c) 3.0 H

(d) 12.5 (e) 0.014 J

24. (a) 8.3×10^{-7} T

(b) 6.25×10^{-7} N; direction to the right

25. (a) (i) force due to electric field is vertically upwards and force due to magnetic force is same size and in opposite direction so there is no unbalanced force on the electrons

(ii) 1.5×10^{6} ms $^{-1}$

(b) same speed as speed is independent of mass ($v = {}^{E}/_{B}$)

(c) r directly proportional to ${}^{q}/_{m}$ which is 2000 larger for electrons so electrons deflection much larger than that of alphas

26. (a) (i) increasing current through inductor creates increasing magnetic field that induces a back emf which opposes the rise in current

(ii) 8.0 Ω

(iii) 0.10 H

(iv) 3.13×10^{-3} J

(b) reading on V_1 rises, reading on V_2 falls; as frequency increases, so does reactance of inductor so current in circuit falls; from Ohm's Law, p.d. across R must decrease and p.d. across inductor rises

27. (a) see notes

(b) (i) 0.036 Nm^{-1}

(ii) apart

(iii) 1.7×10^{-7} T, vertically upwards

(c) 0.038 Nm^{-1}

28. (a) would induce an e.m.f. of 2.0 V across its coil if the current through the inductor was changing at a rate of 1.0 As^{-1}

(b) 6.0 As^{-1}

(c) (i) maximum current is less (Ohm's Law, $I = {}^{V}/_{R}$)

maximum rate of change of current smaller ($^{dI}/_{dt} = {}^{E}/_{R}$)

(ii) 4.69 J

(d) (i) movement of metal through the magnetic field round coil 1 induces an e.m.f. in the metal

(ii) the induced e.m.f. in the metal bracelet makes a current flow round it, triggering the alarm

29. (a) value of resistor R

(b) 0.75 H

(c) 3.75×10^{-3} J

(d) magnetic field of inductor collapses rapidly inducing a large e.m.f. across its ends

30. (a) (i) increasing current through inductor creates increasing magnetic field that induces a back emf which opposes the rise in current and, hence, the increasing brightness of lamp

(ii) 0.25 A

(iii) 2.4 H

(iv) (A) current much less (about two-thirds of first value)

(B) longer to reach maximum current

(b) when switched on, maximum voltage across lamp is 1.5 V so it doesn't light; when switch is opened, magnetic field round inductor collapses rapidly, inducing a b=very large induced emf across the neon lamp - the lamp flashes, dissipating the energy that was stored by the inductor's magnetic field

31. (a) (i) increasing current through inductor creates increasing magnetic field that induces a back emf which opposes the rise in current

(ii) 0.80 A (iii) 0.256 J (0.26 J) (iv) 12.8 As^{-1}

(b) (i) same

(ii) time delay smaller as inductance is much smaller so the induced (back) emf of the inductor is smaller and opposition to increase in current less

(iii) smaller value of inductance

(c) graph starts high when frequency zero and falls towards zero as frequency is increased, steep gradient at first and gradient decreasing as frequency increases

32. (a) (i) use $W = mg$ and $F = {}^{kqq}/_{r}2$

(ii) strong force only acts of a distance of around 10^{-14} m

(b) equate kinetic energy to electric potential energy at distance 'rc'

(c) (i) 1.21×10^{-17} C

(ii) 76 protons (answer 75.5)

(iii) osmium