1)

(a) (i) top plate positive B1
(ii) $E = V/d$ C1
$V = 3.0 \times 10^4 \times 1.2 \times 10^{-2}$
$= 360$ V .... A1 [3]

(b) $F = ma$ C1
$3.0 \times 10^4 \times 1.6 \times 10^{-19} = 9.1 \times 10^{-31} a$ C1
$a = 5.3 \times 10^{15}$ m s^{-2} .... A1 [3]

2)

(a) (i) arrow in upward direction, foot near P B1

(ii) curved path consistent with (i) between plates B1
then straight (with no kink at change-over) .... B1 [3]

(b) $E = V/d$ C1
$= 400 / (0.8 \times 10^{-2})$
$= 5.0 \times 10^4$ V m^{-1} .... (allow 1 sig fig) .... A1 [2]

(c) (i) $F = Eq$ C1
$= 5.0 \times 10^4 \times 1.6 \times 10^{-19}$
$= 8.0 \times 10^{-15}$ N .... (allow 1 sig fig and e.c.f.) A1

(ii) $a = F/m$ C1
$= (8.0 \times 10^{-15}) / (9.1 \times 10^{-31})$
$= 8.8. \times 10^{15}$ m s^{-2} ...... (allow 1 sig fig and e.c.f.) .... A1 [4]

(d) because F_E is normal to <u>horizontal</u> motion M1
no effect .... A1 [2]

3)

(a) (i) arrow from B towards A.. B1

(ii) $E = V/d$
$= 450/(9.0 \times 10^{-2})$ C1
$= 5.0 \times 10^3$ N C^{-1} (accept 1 sig. fig) .... A1 [3]

(b) (i) energy $= qV$ or Eqd C1
$= 1.6 \times 10^{-19} \times 450$.. A1
$= 7.2 \times 10^{-17}$ J.. A0

(ii) $E_k = ½mv^2$
$7.2 \times 10^{-17} = ½ \times 9.1 \times 10^{-31} \times v^2$ C1
$v = 1.26 \times 10^7$ m s^{-1} .... A1 [4]

(c) line from origin, curved in correct direction but not ‘level out’ .... B1 [1]

4)

(a) (i)	lines normal to plate and equal spacing (at least 4 lines) direction from (+) to earthed plate	B1 B1	**[2]**
(ii)	$E = 160/0.08$ $= 2.0 \times 10^3$ V m^{-1}	M1 A0	**[1]**
(b) (i)	correct directions with line of action of arrows passing through charges	B1	**[1]**
(ii)	force $= Eq$ $= 2.0 \times 10^3 \times 1.2 \times 10^{-15}$ $= 2.4 \times 10^{-12}$ N	C1 A1	**[2]**
(iii)	couple = force × perpendicular separation $= 2.4 \times 10^{-12} \times 2.5 \times 10^{-3} \times \sin 35°$ $= 3.4(4) \times 10^{-15}$ N m	M1 A1	**[2]**
(iv)	<u>either</u> **rotates** to align with the field <u>or</u> **oscillates** (about a position) with the positive charge nearer to the earthed plate/clockwise	 M1 A1	**[2]**

5)

(a)	force must be upwards (on positive charge) so plate Y is positive	M1 A1	**[2]**
(b) (i)	$E = V / d$ $= 630/(0.75 \times 10^{-2})$ $= 8.4 \times 10^4$ N C^{-1}	C1 A1	**[2]**
(ii)	$qE = mg$ $q = (9.6 \times 10^{-15} \times 9.8) / (8.4 \times 10^4)$ $= 1.12 \times 10^{-18}$ C	C1 C1 A1	**[3]**

6)

(a)	force <u>per unit positive</u> charge (on a small test charge)	B1	[1]
(b)	field strength = (210/{1.5 × 10^{-2}} =) 1.4 ×10^4 N C^{-1}	A1	[1]
(c) (i)	acceleration = *Eq / m*	C1	
	= (1.4 × 10^4 × 1.6 × 10^{-19}) / (9.1 × 10^{-31})	C1	
	= 2.5 × 10^{15} m s^{-2} (2.46 × 10^{15})	A1	
	towards positive plate / upwards (and normal to plate)	B1	[4]
(ii)	time = 2.4 × 10^{-9} s	A1	[1]
(d)	*either* vertical displacement after acceleration for 2.4 × 10^{-9} s		
	= ½ × 2.46 × 10^{15} × (2.4 × 10^{-9})^2	C1	
	= 7.1 × 10^{-3} m	A1	
	(0.71 cm < 0.75 cm and) so will pass between plates	A1	[3]
	i.e. valid conclusion based on a numerical value		
	or 0.75 × 10^{-2} = ½ × 2.46 × 10^{15} × t^2	(C1)	
	t is time to travel 'half-way across' plates = 2.47 × 10^{-9} s	(A1)	
	(2.4 ns < 2.47 ns) so will pass between plates	(A1)	
	i.e. valid conclusion based on a numerical value		

7)

(a) (i)	*either* force = e × (*V* / *d*) *or* *E* = *V/d*	C1	
	= 1.6 × 10^{-19} × (250 / 7.6 × 10^{-3})	C1	
	= 5.3 × 10^{-15} N	A1	[3]
(ii)	*either* ΔE_K = e*V* *or* ΔE_K = *Fd*	C1	
	= 1.6 × 10^{-19} × 250 = 5.3 × 10^{-15} × 7.6 × 10^{-3}	M1	
	= 4.0 × 10^{-17} J	A0	[2]
	(*allow full credit for correct working via calculation of a and v*)		
(iii)	*either* $\Delta E_K = ½mv^2$		
	4.0 × 10^{-17} = ½ × 9.1 × 10^{-31} × v^2	C1	
	v = 9.4 × 10^6 m s^{-1}	A1	[2]
	or $v^2 = 2as$ and $a = F/m$		
	v^2 = (2 × 5.3 × 10^{-15} × 7.6 × 10^{-3})/(9.11 × 10^{-31}) (C1)		
	v = 9.4 × 10^6 m s^{-1} (A1)		
(b)	speed depends on (electric) potential difference	M2	
	(*If states ΔE_K does not depend on uniformity of field, then award 1 mark, treated as an M mark*)		
	so speed always the same	A1	[3]

8)

(a) **(i)**	$E = V / d$	C1	
	$= 350 / (2.5 \times 10^{-2})$		
	$= 1.4 \times 10^{4}$ N C^{-1}	A1	[2]
(ii)	force = Eq	C1	
	$= 1.4 \times 10^{4} \times 1.6 \times 10^{-19}$	M1	
	$= 2.24 \times 10^{-15}$	A0	[2]
(b) **(i)**	$F = ma$	C1	
	$a = (2.24 \times 10^{-15}) / (9.1 \times 10^{-31})$		
	$= 2.46 \times 10^{15}$ m s^{-2} …(*allow* 2.5×10^{5})	A1	[2]
(ii)	$s = ½at^2$	C1	
	$2.5 \times 10^{-2} = ½ \times 2.46 \times 10^{15} \times t^2$		
	$t = 4.5 \times 10^{-9}$ s	A1	[2]
(c)	*either* gravitational force is normal to electric force		
	or electric force horizontal, gravitational force vertical	B2	[2]
	special case: force/acceleration due to electric field >> force/acceleration due to gravitational field, allow 1 mark		

9)

(a)	charge is quantised / discrete quantities	B1	[1]
(b) **(i)**	parallel so that the electric field is uniform / constant	B1	
	horizontal so that *either* oil drop will not drift sideways		
	or field is vertical		
	or electric force is equal to weight	B1	[2]
(ii)	$qE = mg$	C1	
	$q \times 850 / (5.4 \times 10^{-3}) = 7.7 \times 10^{-15} \times 9.8$	C1	
	$q = 4.8 \times 10^{-19}$ C <u>and is negative</u>	A1	[3]
(c)	charge changes by 1.6×10^{-19} C between droplets / integral multiples	M1	
	so charge on electron is 1.6×10^{-19} C	A0	[1]