10.1 Describing Fields

Question Paper

Course	DP IB Physics
Section	10. Fields (HL only)
Topic	10.1 Describing Fields
Difficulty	Medium

Time allowed: 70

Score: /55

Percentage: /100

Question 1a

(a)

(i)
State what is meant by the gravitational field strength at a point.

[1]

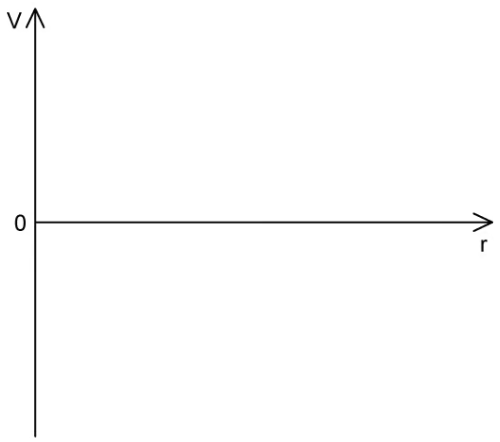
(ii)
Show that the potential V at a distance r above the surface of a planet with radius R is given by $g(R + r)$.

[2]

[3 marks]

Question 1b

(b)
Sketch a graph on the axes provided below to show the relationship between the gravitational potential V with distance r above the surface of the planet.



[2]

[2 marks]

Question 1c

An asteroid, with an initial negligible speed, is gathering pace and is now on a collision-course with the planet.

(c)
Estimate the speed of the asteroid when it reaches the top of the planet's atmosphere, which stretches for 15 km above the planet's surface.

Use the following data:

- Radius of the planet = 3.0×10^6 m
- Gravitational field strength at the top of the atmosphere = 2.5 N kg^{-1}

[3]

[3 marks]

Question 1d

As the asteroid enters the planet's atmosphere, it begins as a small point of light which grows much brighter and faster as it moves towards the surface of the planet.

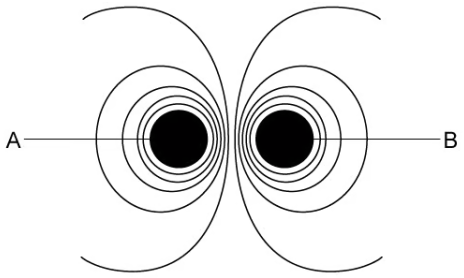
(d)
Discuss these observations. Your answer should make reference to *g* as well as the effect of the planet's atmosphere.

[4]

[4 marks]

Question 2a

Two charged objects, A and B, are brought close together. The equipotential lines around each object is shown.



(a)

(i)

Label a position at which the electric field strength is the strongest with the letter S.

[1]

(ii)

Label a position at which the electric field strength is weakest with the letter W.

[1]

[2 marks]

Question 2b

(b)

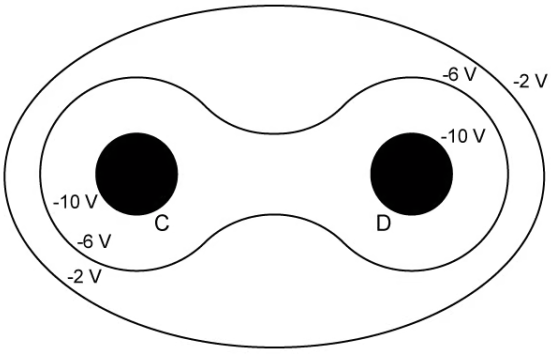
Identify the electric charge on objects A and B and explain your answer.

[3]

[3 marks]

Question 2c

A different pair of equally charged objects, C and D, are brought close together. Equipotential lines at –10 V, –6 V and –2 V around C and D are shown.



(c)
Draw electric field lines between C and D.

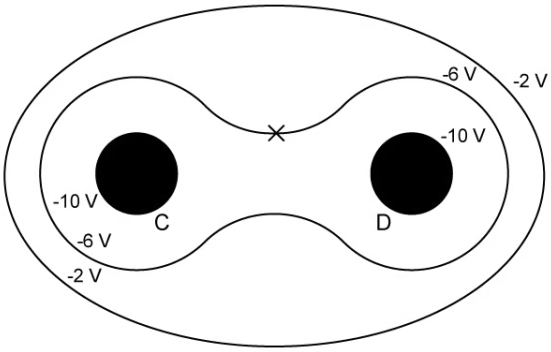
[3]

[3 marks]

Question 2d

Objects C and D are now given a charge of –3.5 nC and –4.0 nC respectively.

X is a position at –6 V which is equidistant from both C and D.



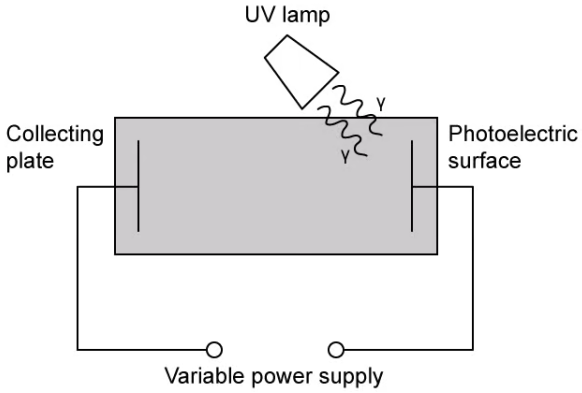
(d)
Determine the potential due to object C at the position labelled X.

[4]

[4 marks]

Question 3a

Hydrogen atoms in an ultraviolet (UV) lamp make transitions from the first excited state to the ground state. Photons are emitted and are incident on a metallic, photoelectric surface as shown.



The photoelectric surface is grounded, and the variable power supply is adjusted so that the electric potential of the collecting surface is 1.5 V.

(a)
Describe the properties of the electric field between the photoelectric surface and the collecting plate.

[2]

[2 marks]

Question 3b

(b)
On the diagram, draw and label equipotential lines at 0.5 V and at 1.0 V.

[2]

[2 marks]

Question 3c

Electrons are released from the photoelectric surface and move toward the collecting plate.

(c)
Determine the work done by the electric field on the electrons as they arrive at the midpoint between the photoelectric surface and the collecting plate.

[2]

[2 marks]

Question 3d

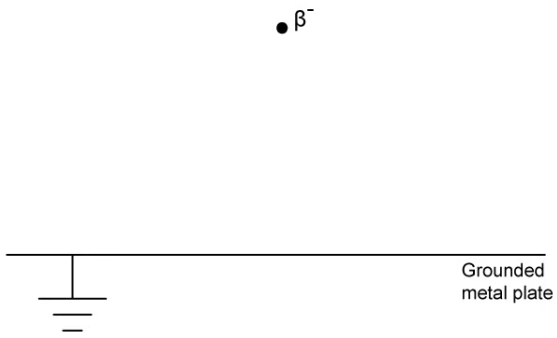
(d)
Describe the motion of the electrons between the photoelectric plate and the collector plate. Your answer should consider the field at the edges of the plates.

[4]

[4 marks]

Question 4a

A β^- particle is placed above a grounded metal plate.



(a)
Sketch the electric field lines between the β^- particle and the metal plate.

[3]

[3 marks]

Question 4b

The β^- particle is replaced with an α particle at the same position above the grounded metal surface.

(b)
Outline the similarities and differences between the electric field now created to that in part (a).

[3]

[3 marks]

Question 4c

The grounded metal surface is removed in order to analyse the combined electric field created between the α particle and the β^- particle.

(c)
Sketch the electric field produced between an α particle and a β^- particle.

[3]

[3 marks]

Question 4d

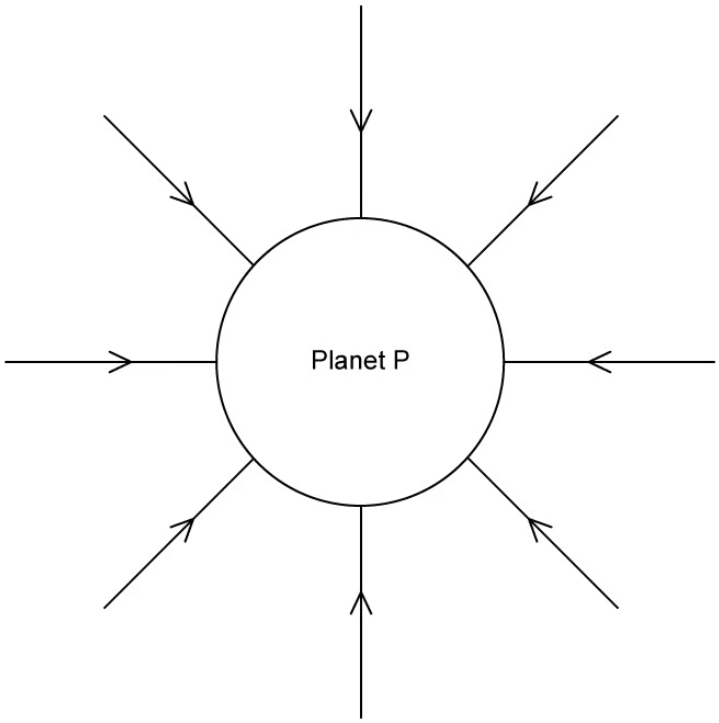
(d)
Discuss whether there is a point of zero electric field for the diagram in part (c).

[2]

[2 marks]

Question 5a

The diagram shows the gravitational field produced by planet P.



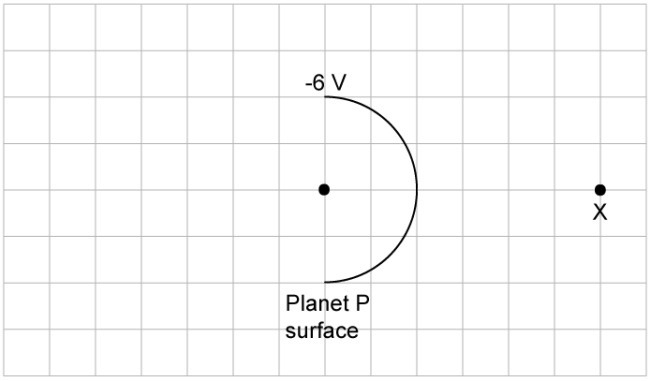
(a)
Outline how this diagram shows that the gravitational field strength of planet P decreases with distance from the surface.

[2]

[2 marks]

Question 5b

The diagram shows part of the surface of planet P. The gravitational potential at the surface of planet P is −6 V and the gravitational potential at point X is −2 V.



(b)
On the grid, sketch and label the equipotential surface corresponding to a gravitational potential of −4 V.

[3]

[3 marks]

Question 5c

A meteorite, very far from planet P, begins to fall to the surface with a negligibly small initial speed. The mass of planet P is 3.0×10^{21} kg and its radius is 2.3×10^{6} m.

(c)
Calculate the speed at which the meteorite will hit the surface, assuming planet P has no atmosphere.

[3]

[3 marks]

Question 5d

(d)
Without detailed calculation, state and explain the effect on the meteorite's impact velocity if planet P's mass was twice as large.

[2]

[2 marks]