The 50

Physics Solutions   —   Fundamentals

For Tutors Only — Not For Distribution

1. (2 marks) Describe Dalton's model of the atom.

> **Solution:** Atoms are made of indivisible spheres.

2. (3 marks) Describe Thomson's model of the atom.

> **Solution:** Plum-pudding model. Atom is ball of positive charge with electrons distributed inside.

3. (4 marks) Describe what was expected to happen in the gold foil experiment and what actually happened. How did this change the model of the atom?

> **Solution:** It was expected that the alpha particles would pass straight through the gold foil. Instead, many particles were deflected and some came straight back. Rutherford explained this result by suggesting an atom consisted of a positively charged nucleus containing most of its mass. He also suggested that outside the nucleus electrons orbit like planets.

4. (2 marks) What is the Bohr model of the atom?

> **Solution:** Bohr realised that orbiting electrons should spiral into the nucleus. With the quantum mechanics, Bohr determined that electrons occupy fixed energy levels, or shells, around the nucleus.

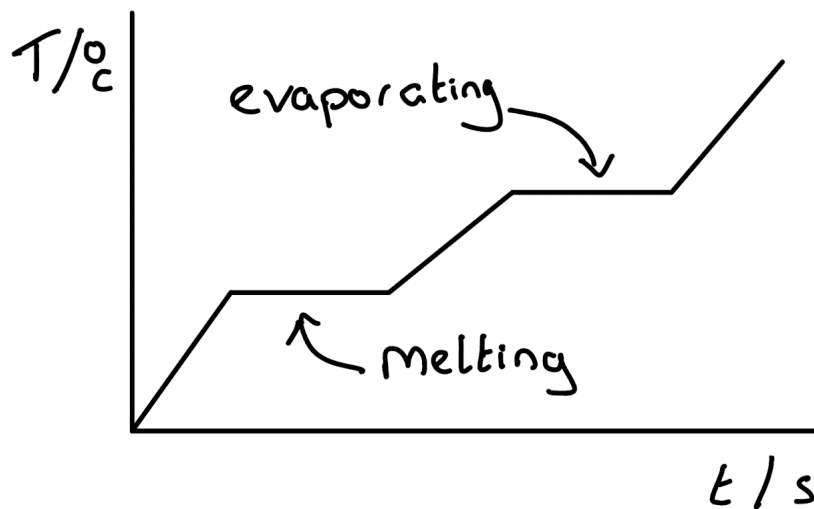5. (3 marks) Draw state diagrams for a solid, liquid and gas.
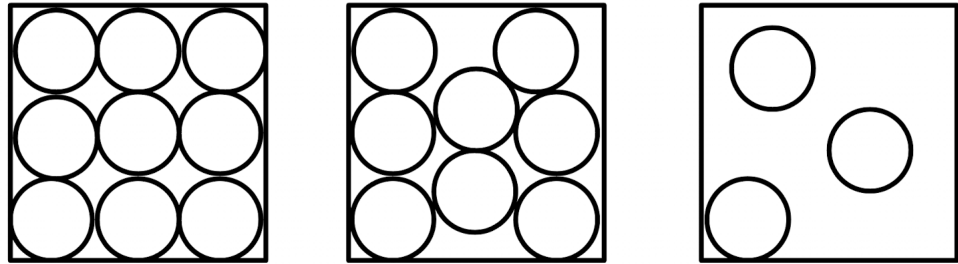
Solution:

6. (2 marks) What is specific heat capacity?

   Solution: The energy required to raise the temperature of 1kg of a substance by $1°C$.

7. (5 marks) Draw a temperature against time graph for a piece of ice that is heated until it boils.

   Solution:

8. (4 marks) Explain how a gas exerts pressure.

   Solution:

   1. Gas particles move randomly.

> 2. Particles collide with the walls of the container.
>
> 3. This exerts a force on the container walls of a given area.
>
> 4. Thus pressure is created as pressure is force divided by area.

9. (4 marks) What happens to pressure as you ascend into the atmosphere and why? What happens to pressure when you dive deeper into the ocean and why?

> **Solution:** Pressure decreases with height as there are fewer particles above you.
>
> Pressure increases with depth as there are more particles above you.

10. (3 marks) Explain how objects float.

> **Solution:** The pressure of the liquid pushing upwards on an object is equal to the weight of the object.

11. (3 marks) What is the difference between a vector and a scalar?

> **Solution:** A vector has magnitude and direction whereas a scalar only has magnitude.

12. (3 marks) List three vectors and three scalars.

> **Solution:** Vectors:
>
> 1. Force
>
> 2. Acceleration
>
> 3. Momentum
>
> Scalars
>
> 1. Speed
>
> 2. Distance
>
> 3. Time

13. (3 marks) What is acceleration? How do you calculate acceleration?

> **Solution:** Acceleration is the rate of change of velocity. $a = \dfrac{\Delta V}{\Delta t}$

14. (2 marks) What do the area and gradient of a velocity-time graph represent?

> **Solution:** Gradient = acceleration. Area = displacement.

15. (6 marks) Draw a free body diagram of a skydiver at various points of their decent (minimum three diagrams).
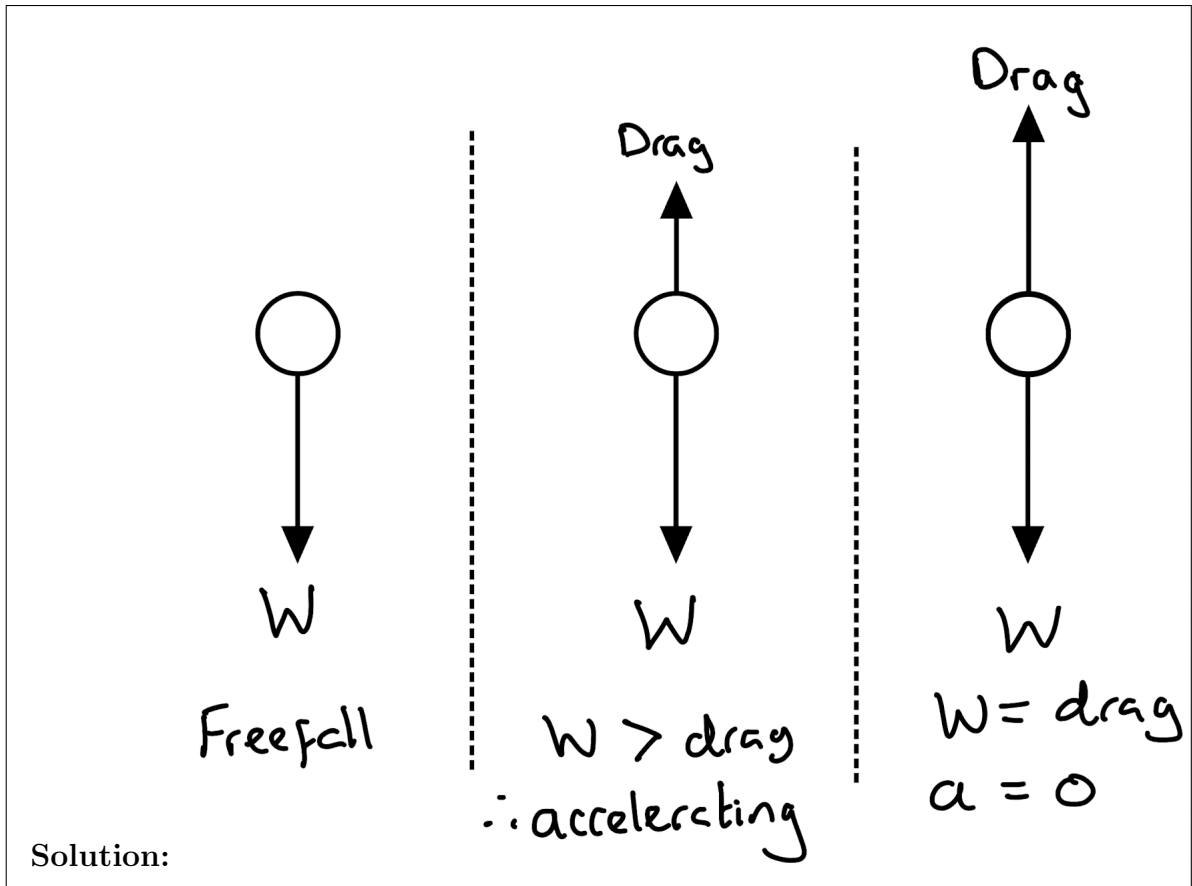
Solution:

16. (2 marks) What is the law of conservation of momentum?

> **Solution:** Total momentum before a collision must equal the total momentum after.

17. (2 marks) What is the difference between an elastic and inelastic collision?

> **Solution:** Elastic collision: Kinetic energy and momentum conserved. Inelastic collision: momentum conserved, not kinetic energy.
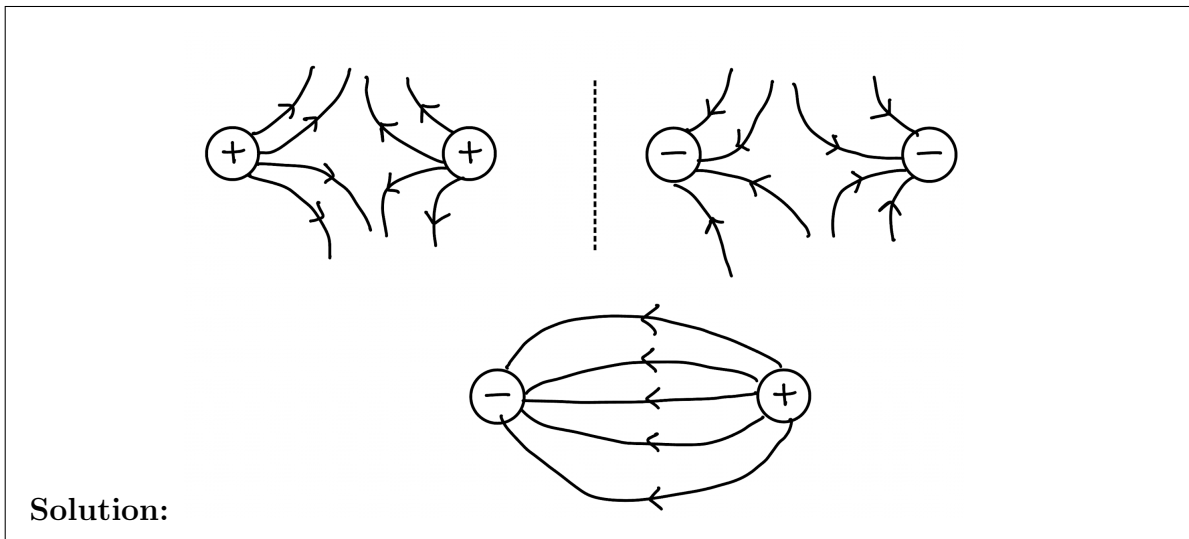
18. (1 mark) Calculate the work done when an object is pushed 5m with a force of 10N.

> **Solution:** $W = 5 \times 10 = 50\text{J}$

19. (2 marks) What is Hooke's law?

> **Solution:** The extension of a spring is directly proportional to force applied. $F = kx$.

20. (3 marks) Draw the electric field of (a) two positive charges (b) two negative charges and (c) one negative and one positive charge.
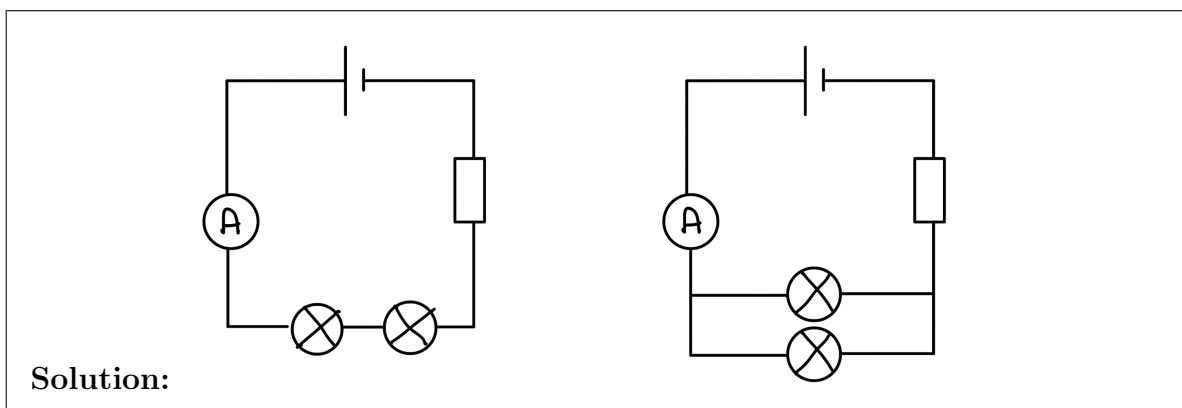

Solution:

21. (2 marks) What is the difference between conventional current and electron flow?

> **Solution:** Conventional current flows from positive to negative (this is what we draw on our diagrams). Electrons flow from negative to positive.

22. (5 marks) Draw the circuit used to determine the resistance of a lamp.
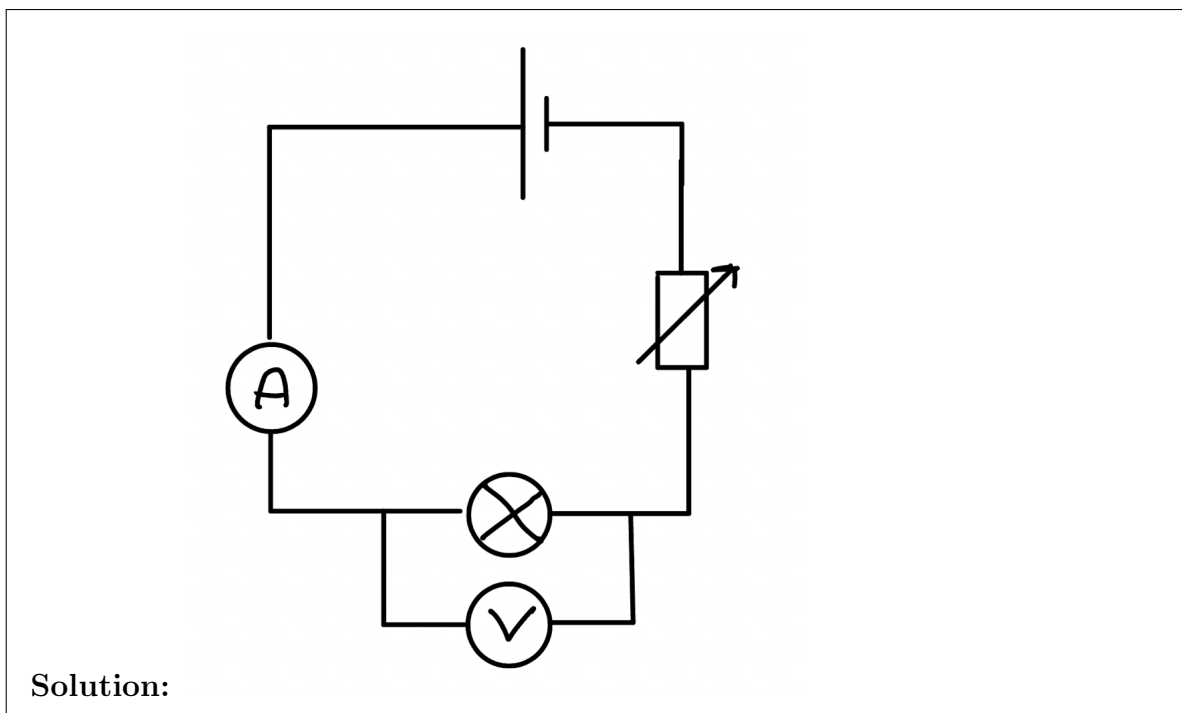
Solution:

23. (3 marks) Draw a series circuit with a cell, resistor, ammeter and two lamps. Draw a parallel circuit with the same components.

Solution:

24. (4 marks) Why does the resistance of a filament lamp increase as it is used?

Solution: As the lamp gets hotter the ions in the metal filament start to vibrate causing more collisions with electrons; thus resistance increases.

25. (3 marks) Draw the I-V characteristic of a diode, filament lamp and fixed resistor.
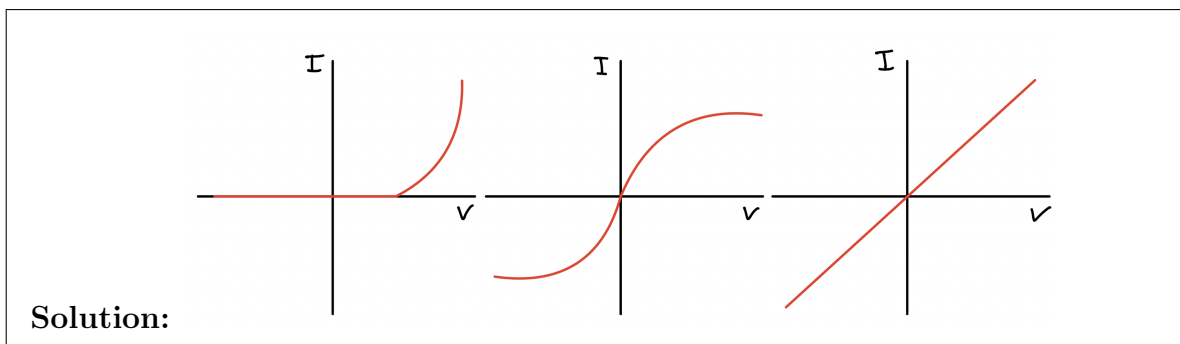
Solution:

26. (2 marks) Describe how the magnetic field of a magnet shows the strength and direction of magnetic forces.

Solution: The density of fields lines represents field strength; The closer the lines the stronger the field.

Arrows on the field lines represent the direction of the magnetic force. Arrows always point away from north and towards south.

27. (2 marks) What does the strength of the magnetic field around a wire depend on?

Solution: The magnitude of the current: a bigger current = a stronger field. The distance from the wire: nearer the wire = a stronger field.

28. (2 marks) State the law of reflection.

Solution: The angle on incidence is the angle of reflection.

29. (2 marks) State the equation for wave speed.

Solution: $v = f\lambda$

30. (1 mark) What is the speed of an electromagnetic wave?

Solution: $3 \times 10^8 \mathrm{m/s}$

31. (7 marks) List the different types of electromagnetic wave.

Solution:

1. Radio

2. Microwave

3. Infrared

4. Visible

5. UV

6. X-ray

7. Gamma

32. (3 marks) Which type of electromagnetic wave has the most energy? Explain why.

Solution: Gamma has the most energy. The energy of an electromagnetic wave is given by $E = hf$, where E is the energy, h is Planck's constant and f is the frequency of the wave.

Therefore, energy is proportional to frequency. Gamma has the highest frequency and thus the most energy.

33. (2 marks) Describe what is inside the nucleus of an atom, and state the charge of the nucleus.

Solution: Protons and neutrons are found in the nucleus of an atom. The overall change of the nucleus is positive. This is because protons are positively charged and neutrons have no charge.

34. (2 marks) What is an isotope?

> **Solution:** Atoms of the same element that have the same number of protons but a different number of neutrons.

35. (4 marks) Describe the types of radiation that unstable nuclei emit.

> **Solution:** Alpha (α), Beta (β), Gamma (γ) and neutron.

36. (4 marks) Order the three types of ionising radiation in terms of (i) ionising power and then (ii) range.

> **Solution:** (i) Alpha, beta and gamma. (ii) Gamma, beta, alpha.

37. (3 marks) Describe in terms of particles what happens in alpha, beta and gamma decay.

> **Solution:** Alpha: emission of helium nucleus (two protons and two neutrons) Beta: emission of electron. Gamma: emission of electromagnetic radiation.

38. (2 marks) Explain what is meant by half-life.

> **Solution:** The time it takes for the activity of a radioactive substance the halve. (This is the same as the time taken for the nuclei of half of the atoms to decay.)

39. (2 marks) Describe the difference between contamination and irradiation.

> **Solution:** Contamination occurs when a object exposed to radioactivity becomes radioactive. For example, if you consumed a radioactive substance, you would become radioactive.
>
> Irradiation occurs when an object is exposed to radiation but does not become radioactive. For example, medical equipment can be sterilized using radioactivity to make it safe to reuse.

40. (3 marks) What is nuclear fission?

> **Solution:** Short answer: large nuclei split into smaller nuclei and release energy.
>
> Some nuclei are unstable and may split into two smaller nuclei. In this process a neutron is released as well as energy in the form of EM radiation. This neutron may collide with another radioactive nucleus and be absorbed, making it unstable. The nucleus then splits, releasing another neutron and more energy.

41. (3 marks) What is nuclear fusion?

> **Solution:** Short answer: small nuclei join together form a larger nucleus and release energy.
>
> Two small nuclei fuse together to form a heavier nucleus, releasing large quantities of energy in the process. The sum of the masses of the two nuclei is **more** than the mass of the larger nucleus because some of the mass is converted into energy and released as radiation.

42. (8 marks) List the 8 types of energy store. (*Bonus: give an example of each and the formula where applicable.*)

> **Solution:**
>
> 1. Chemical
>
> 2. Thermal

> 3. Kinetic
>
> 4. Gravitational
>
> 5. Elastic
>
> 6. Nuclear
>
> 7. Electrostatic
>
> 8. Magnetic

43. (4 marks) How is energy transferred?

> **Solution:**
>
> 1. Mechanically
>
> 2. Electrically
>
> 3. Heating by particles
>
> 4. Heating by radiation

44. (3 marks) Describe, in terms of energy stores, what happens when a car competes in a drag race. (*Start of race: stationary. End of race: maximum speed.*)

> **Solution:**
>
> | Energy Store | Start of Race | Transfer | End of race |
> |---|---|---|---|
> | Kinetic | Empty | | More KE |
> | Thermal | Some thermal energy | Mechanical | More thermal energy |
> | Chemical | Full | | Less chemical energy |

45. (3 marks) Describe, in terms of energy stores, what happens when you throw a ball into the air until it stops momentarily at the top of its flight.

Solution:

Energy Store	Start of Race	Transfer	End of race
Kinetic	More KE		Zero KE
Thermal	Some thermal energy	Mechanical	More thermal energy
Gravitational	Some GPE		More GPE

46. (3 marks) Why is electricity transported across the national grid at high voltages?

> **Solution:**
>
> For electricity, decreasing current will increase efficiency, as power loss in heating wires is due to current and resistance:
>
> $$P_{\text{lost}} = I^2 R$$
>
> A higher voltage means a lower current and therefore less energy is wasted.

47. (4 marks) What is thermal conductivity? How does thermal conductivity of the walls of a house affect the rate of cooling?

> **Solution:** Thermal conductivity is a measure of how quickly energy is transferred, and in this context, how much energy is transferred through a wall.
>
> The higher the thermal conductivity, the faster the house will cool down.

48. (3 marks) What factors affect thinking distance? What factors affect breaking distance? What factors affect stopping distance?

> **Solution:** Thinking: alcohol, drugs, tiredness, speed. Braking: Condition of tyres, weather, mass of vehicle, speed. Stopping: Speed.

49. (3 marks) How do seatbelts and airbags protect you in a car collision?

Solution: If the car slows down suddenly, the belt exerts a force on you. Without it, you would continue to move with your original speed, and collide with the dashboard or the seat in front of you, causing injury to yourself or others.

In addition to physically stopping you hitting the dashboard and windscreen, both the seat belts and airbags reduce the force that acts on your body as you stop. They reduce your acceleration. Remember, $F = ma$ so lowering acceleration reduces the net force acting on the body.

50. (3 marks) Explain the evidence for the Big Bang model.

Solution:

1. Red shift: shows the universe is expanding.

2. Cosmic Microwave Background Radiation: If the universe started in a hot dense state, the wavelength of this radiation would have been stretched to become microwaves. This is predicted by the Big Bang model and we see this when we look into space.