Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2005

PHYSICS

CHIEF EXAMINER'S REPORT
HIGHER AND ORDINARY LEVELS

Contents

1. INTRODUCTION

1.1 The Syllabus

The revised Leaving Certificate Physics Syllabus was introduced in 2000 and first examined in 2002. The syllabus contains two separate sections, one for Higher Level and one for Ordinary Level, and incorporates the components pure physics, applications of physics and physics issues of concern to citizens. Pure physics which includes principles, procedures and physics concepts has a 70% weighting while the remaining 30% is allocated to the other two components. The Higher Level syllabus contains two options which are not on the Ordinary Level syllabus.

1.2 The Examination

Physics at both Higher and Ordinary levels is assessed by means of a terminal written examination of three hours duration, marked out of 400 marks.
The paper is divided into two sections – A and B.

- Section A (30%) assesses the experiments listed in the syllabus that are required to be completed by the candidates during their course of study – three questions are to be answered from four given questions (40 marks each).

- Section B (70%) assesses the general syllabus content, including practical work – five questions are to be answered from eight given questions (56 marks each).

- Question 5 consists of ten short items, of which eight items are to be answered.

- Question 12 consists of four parts, of which two parts are to be answered.

- At Higher Level in 2005, Question 11 examined the two options in the syllabus – Applied Electricity and Particle Physics. There are no options at Ordinary Level.

- There is no compulsory question on either examination paper.

- Appropriate data are provided in the relevant questions on the Higher Level paper.

- Appropriate formulae and data are provided in the relevant questions on the Ordinary Level paper.

1.3 Candidature

Table 1 shows the number of candidates sitting Leaving Certificate Physics for the last four years.

				Higher Level		Ordinary Level	
Year	**LC candidates**	**% taking Physics**	**Physics candidates**	**Candidates**	**%**	**Candidates**	**%**
2002	55496	15.6%	8651	5987	69.2%	2664	30.8%
2003	56237	15.7%	8806	6175	70.1%	2631	29.9%
2004	55222	14.8%	8148	5836	71.6%	2312	28.4%
2005	54069	14.7%	7944	5508	69.3%	2436	30.7%

Table 1: Numbers of Leaving Certificate Physics candidates 2002-2005

2. PERFORMANCE OF CANDIDATES

Tables 2 and 3 show the numbers and percentages of candidates achieving each grade in the 2005 Higher Level and Ordinary Level Physics examinations.

Grade	**A**	**B**	**C**	**D**	**E**	**F**	**NG**	**Total**
Numbers	1124	1561	1264	1074	320	142	23	5508
% of candidates	20.4%	28.3%	22.9%	19.5%	5.8%	2.6%	0.4%	100.0%

Table 2: Numbers of candidates achieving each grade in higher level Physics in 2005

Grade	**A**	**B**	**C**	**D**	**E**	**F**	**NG**	**Total**
Numbers	430	732	557	440	153	94	30	2436
% of candidates	17.7%	30.0%	22.9%	18.1%	6.3%	3.9%	1.2%	100.0%

Table 3: Numbers of candidates achieving each grade in Ordinary level Physics in 2005

Tables 4 and 5 show the average percentage mark per question and the response rate in individual questions. The response rate is given as the percentage of candidates attempting each question in each section. Data in Table 4 are based on a random sample of 800 scripts, approximately 15% of the total Higher Level cohort. Data in Table 5 are based on a random sample of 320 scripts, approximately 13% of the total Ordinary Level cohort.

Section	Question	Topic	average % mark	rank order	response rate (%)	rank order
A	1	Momentum	76.5%	1	92.5%	2
	2	Specific latent heat	65.3%	3	77.3%	3
	3	Snell's law	74.7%	2	95.1%	1
	4	*I-V* for bulb	64.7%	4	44.9%	4
B	5	General	72.5%	1	98.3%	1
	6	Satellite	62.2%	4	63.4%	5
	7	Wave motion	46.1%	7	64.3%	4
	8	Radioactivity	49.1%	6	54.1%	8
	9	Current electricity	41.2%	8	57.4%	6
	10	Electrostatics	54.6%	5	57.1%	7
	*11(a)	Particle accelerator	69.8%	2	66.3%	3
	*11(b)	Electromagnetism	31.1%	9	16.1%	9
	12	General	64.3%	3	90.7%	2

Table 4: Performance of candidates and response rates in Higher Level Physics 2005
* Question 11 had an internal choice between (a) and (b).

Section	Question	Topic	Average % mark	rank order	response rate (%)	rank order
A	1	Force v acceleration	74.0%	2	84%	1
	2	Specific latent heat	79.8%	1	74%	2
	3	Converging lens	73.5%	3	64%	4
	4	Resistivity	73.5%	3	68%	3
B	5	General	77.5%	1	97%	1
	6	Pressure	56.4%	6	68%	4
	7	Optics	57.7%	5	61%	5
	8	Current electricity	60.0%	3	38%	8
	9	Electromagnetism	52.9%	8	57%	6
	10	Electron	61.1%	3	57%	6
	11	Energy	61.6%	2	85%	2
	12	General	55.4%	7	80%	3

Table 5: Performance of candidates and response rates in Ordinary Level Physics 2005

Comments

- In Section A of the Higher Level paper, 3.6% of the candidates failed to attempt the required three questions, while 13.1% of the candidates attempted all four questions.

- In Section B of the Higher Level paper, 3.8% of the candidates did not attempt the required five questions while 43.6% attempted more than five.

- 38% of the Ordinary Level candidates attempted more than the required number of questions.

- 60% of Ordinary Level candidates who were awarded a grade A attempted more than the required number of questions.

- 69% of Ordinary Level candidates who were awarded a grade E, F or NG did not attempt the required number of questions.

3. ANALYSIS OF CANDIDATE PERFORMANCE

3.1 Higher Level

Section A

Question 1 **Average mark 30.6 (77%)** **Response rate 93%**

- Draw a diagram of the apparatus used in the experiment. (9)

  The ticker tape timer involving the use of trolleys was the most commonly used apparatus. The air track arrangement with riders and a card was occasionally presented. Both methods were well answered. The main error was the omission to indicate how the trolleys/riders joined together.

- Describe how the time interval of 0.2 s was measured. (6)

  Generally well answered. Higher scores were gained with the ticker timer. A minority of candidates stated incorrectly that the time between dots was 0.2 s. Candidates showing light gates often failed to refer to the time measurement.

- Calculate the velocity of the body A (i) before, (ii) after, the collision. (6)

  Well answered with a few candidates omitting to indicate the units of velocity. A small number used conservation of momentum to find the 'velocity after'.

- Show how the experiment verifies the principle of conservation of momentum. (12)

  Very well answered throughout with a few omitting units for momentum. On occasions, verification of the principle was not clearly stated as a consequence of calculations.

- How were the effects of friction and gravity minimised in the experiment? (7)

  Very few candidates treated both effects separately with many scoring only 4/7 marks as a consequence. Common answers included: ‘slope the track’ and ‘oil/clean’. Minimisation of the effects of gravity was frequently omitted. Rarely was reference made to the fact that the trolley moved with constant velocity in the experiment.

Question 2 **Average mark 26.1 (65%)** **Response rate77%**

- Calculate a value for the specific latent heat of vaporisation of water. (24)

  Formula and calculations generally accurately presented. Units in final answer frequently omitted or incorrect (e.g. J or J kg^{-1} K^{-1}).

- Why was dry steam used? (6)

  A variety of vague imprecise answers were given by many candidates, e.g. water in steam would have an effect on the measured mass of water.

- How was the steam dried? (4)

  Very well answered by all candidates. The most common answer was 'steam trap'. A minority used an insulated or sloped delivery tube.

- A thermometer with a low heat capacity was used to ensure accuracy. Explain why. (6)

  Incomplete answering was common with many candidates not fully comprehending the meaning of heat capacity and most neglecting to indicate from where the thermometer absorbed the heat energy. Many candidates stated that the thermometer was more accurate or more sensitive.

Question 3 Average mark 29.9 (75%) Response rate 95%

- Describe, with the aid of a diagram, how the candidate obtained the angle of refraction. (9)

  Most candidates gave a very detailed account but omitted to mention 'measure *r'*. Occasionally, *r* was misplaced, shown either between the refracted ray and the interface or at the emergent ray.

- Draw a suitable graph on graph paper and explain how your graph verifies Snell's law. (18)

  Well answered with many candidates gaining full marks. A small number of candidates drew an artificial straight line so that it passed through all the points.

  Candidates should make sure that their calculators are in the correct mode when using angles. Candidates lost many marks when using the radian mode. The penalty for gradian mode was less severe as this mode resulted in a graph similar to the correct one.
  Most candidates gave the correct conclusion for the verification of Snell's law.

- From your graph, calculate the refractive index of the substance. (9)

  Generally well answered. Some candidates were penalised for using data points which were not on the straight line. A few neglected to calculate the reciprocal of the slope in order to obtain the value for the refractive index.

- The smallest angle of incidence chosen was 20^{o}. Why would smaller values lead to a less accurate result? (4)

  Reasonably well answered with a significant number of candidates omitting the word 'percentage'. A small number referred to critical angle and total internal reflection.

Question 4 Average mark 25.9 (65%) Response rate 45%

- Draw a suitable circuit diagram used by the candidate. (12)

  Most candidates earned full marks. Common errors included no voltmeter, voltmeter in series, rheostat used as a potential divider but incorrect connections used, and ammeter positioned on battery side of potential divider.

- Describe how the candidate varied the potential difference. (4)

  Very well answered by the vast majority who said ‘adjust the sliding contact of the rheostat’.

- With reference to the graph, explain why the current is not proportional to the potential difference. (3)

  Detailed descriptive work by many candidates regarding R changing but some candidates failed to relate their answers to the graph.

- With reference to the graph, calculate the change in resistance of the filament bulb as the potential difference increases from 1 V to 5 V. (15)

  Many candidates did not achieve full marks. Common errors included the use of mA instead of A, incorrect values for current taken from the graph, incorrect calculation for *R*.

- Give a reason why the resistance of the filament bulb changes. (6)

  Poorly answered with a substantial number of candidates not referring to the ‘filament’.

Section B

Question 5 **Average mark 40.6 (73%)** **Response rate 98%**

(a) A container contains 5.0 kg of water. If the area of the base of the container is 0.5 m^2 calculate the pressure at the base of the container due to the water. (7)

Reasonably well answered but a significant number of candidates attempted a solution using: $P = h\rho g$

(b) State Boyle's law. (7)

Well answered, but 'fixed mass of gas' and 'constant temperature' were often omitted.

(c) What is the thermometric property of a thermocouple? (7)

Well answered. A number gave 'resistance' as the answer and others simply defined thermometric property.

(d) An object O is placed 30 cm in front of a concave mirror of focal length 10 cm. How far from the mirror is the image formed? (7)

Most candidates earned full marks.

(e) A capacitor of capacitance 100 μF is charged to a p.d. of 20 V. What is the energy stored in the capacitor? (7)

Fairly well answered. Some candidates attempted to use $Q = CV$, while others erred with conversion of units, and arithmetic error was reasonably common (e.g. forgetting to square voltage value).

(f) Draw a sketch of the magnetic field due to a long straight current-carrying conductor. (7)

Fairly well answered with directions clearly shown. Some candidates drew the magnetic field around a bar magnet.

(g) A pear-shaped conductor is placed on an insulated stand is shown. Copy the diagram and show how the charge is distributed over the conductor when it is positively charged. (7)

Very well answered. A small number of candidates indicated high charge density at pointed end but neglected to indicate any presence of charge on the rest of the conductor.

(h) Explain why high voltages are used in the transmission of electrical energy. (7)

Most candidates gave detailed answers but frequently neglected to refer to the use of ‘smaller currents’ in the transmission process.

(i) How are electrons produced in an X-ray tube? (7)

Excellent answers but many candidates misinterpreted the question asked and as a result gave an unnecessary full account of X-ray production.

(j) Name the fundamental force of nature that holds the nucleus together. **or** Draw the truth table for the AND gate. (7)

‘Strong nuclear force’ known by the vast majority of candidates. The AND gate question was unpopular but generally correct when attempted.

Question 6 **Average mark 34.9 (62%)** **Response rate 64%**

- Define (i) angular velocity: Well answered by most candidates.

- Define (ii) centripetal force: Well answered but a number of candidates omitted 'towards centre'.

- State Newton's Universal Law of Gravitation. (18)

  Well answered.

- A satellite is in a circular orbit around the planet Saturn. Derive the relationship between the period of the satellite, the mass of Saturn and the radius of the orbit. (15)

  Either correctly answered or only the final formula given. In the latter case, T was often written instead of T^2.

- The period of the satellite is 380 hours. Calculate the radius of the satellite's orbit around Saturn. (9)

  Generally well answered. Errors included: π not squared and taking the square root instead of the cube root of r.

- The satellite transmits radio signals to earth. At a particular time the satellite is 1.2×10^{12} m from earth. How long does it take the signal to travel to earth? (9)

  Well answered by most candidates. A small number attempted to use the derived formula.

- It is noticed that the frequency of the received radio signal changes as the satellite orbits Saturn. Explain why. (5)

  Poorly answered by the majority of candidates who simply gave the standard definition for the Doppler effect, often omitting reference to 'relative motion'. Rarely did a candidate link the frequency change to the satellite moving towards and then away from the earth.

Question 7 **Average mark 25.8 (46%)** **Response rate 64%**

- A candidate used a laser, as shown, to demonstrate that light is a wave motion. Name the two phenomena that occur when light passes through the pair of narrow slits. (6)

  Reasonably well answered. A variety of incorrect answers included polarisation, refraction, etc.

- A pattern is formed on the screen. Explain how the pattern is formed. (12)

  Poorly answered. Many candidates did not directly address the question asked and the majority rarely mentioned 'coherent sources'.

- What is the effect on the pattern when the wavelength of the light is increased? (4)

  Many did not refer to the 'effect on the pattern', often stating 'brighter images'.

- What is the effect on the pattern when the distance between the slits is increased? (4)

  Poorly answered.

- Describe an experiment to demonstrate that sound is also a wave motion. (12)

  The majority used the two loudspeaker experiment but often omitted the signal generator or simply labelled it 'a sound source'. Some attempts included the bell in vacuum jar experiment and showing wave form using a microphone and oscilloscope.

- Sound travels as longitudinal waves while light travels as transverse waves. Explain the difference between longitudinal and transverse waves. (9)

  Quite well answered but often imprecise with no mention of 'vibrations'. Generally, the concepts of 'parallel' and 'perpendicular' were well known but many failed to correctly link them to 'vibrations' and 'direction'.

- Describe an experiment to demonstrate that light waves are transverse waves. (9)

  Often poorly answered. Many gave the ‘crossed’ polaroids only and failed to rotate one relative to the other. The most common error involved simple use of the polarisation model using slits in cardboard.

Question 8 Average mark 27.5 (49%) Response rate 54%

- Nuclear disintegrations occur in radioactivity and in fission. Distinguish between radioactivity and fission. (12)

  Radioactivity definition well known but many candidates omitted emission of neutrons in fission.

- Give an application of radioactivity

  Well answered. ‘Cancer treatment’ was a common answer.

- Give an application of fission.

  Fair answers, with many not stating ‘electrical (energy)’.

- Radioactivity causes ionisation in materials. What is ionisation? (3)

  Vague answers often given which failed to make reference to ‘atom’.

- Describe an experiment to demonstrate the ionising effect of radioactivity. (12)

  Apparatus and procedure were well described in the case of a charged electroscope method but the conclusion was poorly stated. Some candidates incorrectly used ultra violet light as the radiation. A number used a Geiger counter to compare the penetration of different radiations but did not refer to ionisation.

- Cobalt-60 is a radioactive isotope with a half-life of 5.26 years and emits beta particles. Write an equation to represent the decay of cobalt-60. (9)

  Many candidates did not score full marks. The problem appeared to be a confusion between atomic and mass numbers. Many failed to identify Ni as the product.

- Calculate the decay constant of cobalt-60. (8)

  Formula well known and used correctly. Unit often omitted or incorrect.

- Calculate the rate of decay of a sample of cobalt-60 when it has 2.5×10^{21} atoms. (6)

  Well answered. The main error involved the unit. A number of candidates used Avogadro's constant in their calculations.

Question 9 **Average mark 23.1 (41%)** **Response rate 57%**

- Define p.d.

  Well answered. Many gave formula and correct notation. A small number gave $V = IR$.

- Define Resistance.

  Less well answered. A number gave answers like 'opposition to flow of current'.

- Two resistors are connected in parallel. Derive an expression for the effective resistance of the two resistors (12)

  Fairly well answered. Poor attempts included those in which voltages were initially added rather than currents or a misuse of Ohm's law. On occasions, candidates presented the final expression without any derivation.

- In the circuit diagram, the resistance of the thermistor at room temperature is 500 Ω. At room temperature, calculate the total resistance of the circuit. (9)

  Well answered by the majority.

- Calculate the current flowing through the 750 Ω resistor. (9)

  Poorly answered. Common error was $I = 6/750$ A.

- As the temperature of the room increases, explain why the resistance of the thermistor decreases. (7)

  Poorly answered with many not stating that the energy/temperature of the thermistor increased. Few correctly involved the electron in their explanation.

- As the temperature of the room increases, explain why the potential at A increases. (7)

  Very poorly answered. The concept of the potential at A was not understood by many of the candidates.

Question 10 Average mark 30.6 (55%) Response rate 57%

- Define electric field strength. (6)

  Well answered. Common wrong answer was 'charge per unit area'.

- State Coulomb's law of force between electric charges. (6)

  Well answered. A small number of candidates gave an expression which did not contain *F*.

- Why is Coulomb's law an example of an inverse square law? (6)

  Well answered.

- Give two differences between the gravitational force and the electrostatic force between two electrons. (6)

  Many candidates gave general answers rather than specifically referring to two electrons.

- Describe an experiment to show an electric field pattern. (12)

  Many candidates failed to gain full marks here due to omission of the H.T. supply. A few candidates used water as the liquid. Other candidates described magnetic field experiments.

- Calculate the electric field strength at the point B, which is 10 mm from an electron. (9)

  Many candidates did not know the correct formula for *E* and tried to use Coulomb's law. Errors occurred when substituting for distance. Some candidates used 10 mm for the distance and others converted it incorrectly to 0.001 m

- What is the direction of the electric field strength at B? (3)

  Fairly well answered. This was not answered by some candidates.

- A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge. (8)

Generally well answered with most candidates using Coulomb's law. Consequently, the same mistakes occurred here as above when substituting for distance.

Most candidates failed to recognise the vector nature of F and didn't give its direction.

Question 11(a) **Average mark 39.1 (70%)** **Response rate 66%**

(i) What is the structure of an alpha particle? (7)

Most gave helium or ${}^{4}_{2}He$. Some answers were inconsistent, e.g. 'a helium nucleus containing 2 p, 2 n and 2 e'.

(ii) Rutherford had bombarded gold foil with alpha particles. What conclusion did he form about the structure of the atom? (7)

Reasonably well answered, although some candidates omitted 'positive charge', while others mentioned only 'empty space' or referred to 'nucleus' and 'orbiting electrons'.

(iii) High voltages can be used to accelerate alpha particles and protons but not neutrons. Explain why. (7)

Well answered but many confined their answer to the zero charge on the neutron and failed to state that the proton and alpha particle were both charged.

(iv) Cockcroft and Walton, under the guidance of Rutherford, used a linear particle accelerator to artificially split a lithium nucleus by bombarding it with high-speed protons. Copy and complete the following nuclear equation for this reaction. (7)

Very well answered.

(v) Circular particle accelerators were later developed. Give an advantage of circular accelerators over linear accelerators. (7)

A variety of answers most of which were acceptable. 'Higher speed' was often given.

(vi) In an accelerator, two high-speed protons collide and a series of new particles are produced, in addition to the two original protons. Explain why new particles are produced. (7)

Most candidates seemed to have some idea of the answer but were circumspect. Some candidates gave quite complex explanations without linking mass and energy directly. Other incomplete answers were ‘energy is conserved when new particles are formed’.

(vii) A huge collection of new particles was produced using circular accelerators. The quark model was proposed to put order on the new particles. List the six flavours of quark. (7)

Very well answered.

(viii) Give the quark composition of the proton. (7)

Very well answered.

Question 11(b) **Average mark 17.4 (31%)** **Response rate 16%**

(i) List three factors that affect the force on a current-carrying conductor placed near a magnet. (7)

Most candidates gave ‘current’ but not always ‘B’ or ‘length’. A typical unacceptable answer was ‘strength of the magnetic field’.

(ii) What energy transformation takes place in an electric motor? (7)

Fair, but a number reversed the order and gave ‘E_k to electrical’.

(iii) What is the function of a commutator in a dc motor? (7)

Not well known.

(iv) Draw a sketch of the output voltage from an ac generator. (7)

Poorly answered, often with time not shown and graph not sinusoidal e.g. half wave rectification.

(v) How are the slip rings connected to an external circuit in an ac generator? (7)

Fair. Most candidates gave carbon brushes.

(vi) A transformer and an induction coil can both be used to change a small voltage into a larger voltage. What is the basic difference in the operation of these two devices? (7)

Poor understanding of both devices. Some references to transformers 'using mutual induction' or to both devices having 'two coils'.

(vii) Name the Irish physicist who invented the induction coil. (7)

Well known.

(viii) Give two factors that affect the efficiency of a transformer. (7)

Seldom fully answered. 'Eddy currents' and 'heat losses' were common answers. A number of candidates responded to the question by suggesting how the efficiency might be improved.

Question 12 **Average mark 36.0 (64%)** **Response rate 91%**

In Q12, 25.3% of the candidates attempted more than the two required parts. The internal choice in the question resulted in part (a) being ranked first in both average mark (19.9 marks) and in response rate (82.3%). Part (b), on the other hand, was ranked 4^{th} under the same headings.

part	Average mark	Average % mark	Rank order	Response rate (%)	Rank order
(a)	19.9	70.9%	1	82.3%	1
(b)	15.1	54.0%	4	27.3%	4
(c)	17.9	63.8%	2	54.0%	2
(d)	16.7	59.5%	3	53.6%	3

Question 12 (a) **Average mark 19.0 (71%)** **Response rate 82%**

- State the principle of conservation of energy. (6)

  Well known.

  A basketball of mass 600 g which was resting on a hoop falls to the ground 3.05 m below. What is the maximum kinetic energy of the ball as it falls? (9)

  Well answered. A number of candidates used $v^2 = u^2 + 2as$ and often carelessly rounded off the value for v before final substitution to find E_k.

- On bouncing from the ground the ball loses 6 joules of energy. What happens to the energy lost by the ball? (4)

  'Sound' was the most common correct answer. A few stated 'energy goes into the ground' or 'it is converted into potential'.

- Calculate the height of the first bounce of the ball. (9)

  Generally well answered. A few incorrectly used the 6 J to calculate h.

Question 12 (b) Average mark 15.1 (54%) Response rate 27%

- Define magnetic flux. (6)

  Some confusion with flux and flux density. Some candidates introduced the equation $F = BIl$ in an effort to define φ.

- State Faraday's law of electromagnetic induction. (6)

  Well answered.

- A square coil of side 5 cm lies perpendicular to a magnetic field of flux density 4.0 T. The coil consists of 200 turns of wire. What is the magnetic flux cutting the coil? (9)

  Not well answered. Often 5 cm was used not converted while n =200 was used incorrectly.

- The coil is rotated through an angle of 90^o in 0.2 seconds. Calculate the magnitude of the average e.m.f. induced in the coil while it is being rotated. (7)

  Fairly well answered even though the significance of the angle was misunderstood by some candidates.

Question 12 (c) Average mark 17.9 (64%) Response rate 54%

- The frequency of a stretched string depends on its length. Give two other factors that affect the frequency of a stretched string. (6)

  Usually 'tension' was the only correct answer. Common wrong answers included 'thickness', 'mass of string'.

- The diagram shows a guitar string stretched between supports 0.65 m apart. The string is vibrating at its first harmonic. The speed of sound in the string is 500 m s^{-1}. What is the frequency of vibration of the string? (9)

  Well answered. Often λ =0.65 m was used leading to the incorrect answer λ =769 Hz.

- Draw a diagram of the string when it vibrates at its second harmonic. (7)

  Well answered.

- What is the frequency of the second harmonic? (6)

  Well answered with the majority simply doubling the answer they obtained earlier for the 1^{st} harmonic.

Question 12 (d) Average mark 16.7 (60%) Response rate 54%

- One hundred years ago, Albert Einstein explained the photoelectric effect. What is the photoelectric effect? (6)

  Well answered. A number of candidates omitted ‘suitable’ or used ‘certain’ in its place, when referring to the frequency of the radiation.

- Write down an expression for Einstein’s photoelectric law. (9)

  Well answered. A small number of candidates used *E* instead of *hf*.

- Summarise Einstein’s explanation of the photoelectric effect. (9)

  Most candidates earned 6 marks out of 9. Failure to state that ‘all of the energy from one photon is given to one electron’ was a common error.

- Give one application of the photoelectric effect. (4)

  Well answered, with ‘sound track in films’, ‘photocell’ and ‘burglar alarms’ as common applications.

3.2 Ordinary Level

Section A

Question 1 **Average mark 74%** **Response rate 84%**

- In an experiment to investigate the relationship between force and acceleration a candidate applied a force to a body and measured the resulting acceleration. Draw a labelled diagram of the apparatus used in the experiment. (9)

  Well answered.

- Outline how the candidate measured the applied force. (6)

  Many candidates had difficulties in outlining how the candidate measured the applied force.

- Plot a graph, on graph paper of the acceleration against the applied force. Put acceleration on the horizontal axis (X-axis). (12)

  Well answered.

- Calculate the slope of your graph and hence determine the mass of the body. (9)

  Some candidates had difficulties determining the slope, either not taking the points from the graph or inverting the values in the formula.

- Give one precaution that the candidate took during the experiment. (4)

  The precaution mentioned was often poor, and very general.

Question 2 **Average mark 80%** **Response rate 74%**

- In a report of an experiment to measure the specific latent heat of vaporisation of water, a candidate wrote the following…

  Draw a labelled diagram of the apparatus used. (12)

  Well answered. Some candidates omitted the thermometer. Some others had heating coils or ice in the diagram indicating confusion with other experiments.

- How did the candidate find the mass of steam that was added to the water? (9)

  Well answered.

- How did the candidate make sure that only steam, and not hot water, was added to the calorimeter? (6)

  Poorly answered.

- List two measurements that the candidate took before adding the steam to the water. (9)

  Well answered.

- Give one precaution that the candidate took to prevent heat loss from the calorimeter. (4)

  Well answered.

Question 3 **Average mark 73%** **Response rate 64%**

- You carried out an experiment to measure the focal length of a converging lens. Draw a labelled diagram of the apparatus that you used in the experiment. (12)

  Well answered.

- Describe how you found the position of the image formed by the lens. (6)

  Some candidates had a mirror instead of a lens. Many candidates failed to convey the idea of a ‘clear’ image on the screen.

- What measurements did you take? (9)

  Well answered.

- How did you get a value for the focal length of the converging lens from your measurements? (9)

  Weaker candidates did not know how to get focal length.

- Give one precaution that you took to get an accurate result. (4)

  Well answered.

Question 4 **Average mark 74%** **Response rate 68%**

- In an experiment to measure the resistivity of the material of a wire, a candidate measured the length, diameter and the resistance of a sample of nichrome wire. Describe how the candidate measured the resistance of the wire. (6)

  Well answered.

- Name the instrument used to measure the diameter of the wire. Why did the candidate measure the diameter of the wire in three different places? (12)

  Many candidates used 'Vernier callipers' instead of 'micrometer'.

- Using the data, calculate the diameter of the wire. Hence calculate the cross-sectional area of the wire. (12) Calculate the resistivity of nichrome using the formula. (6)

  Many candidates had mistakes in the calculations, especially in the order of magnitude of the figures. Some candidates used the diameter as the radius; others confused r (radius,) and R (resistance).

- Give one precaution that the candidate took when measuring the length of the wire. (4)

  Many of the precautions given were not relevant to measuring the length of the wire.

SECTION B

Questions 5, 11 and 12 respectively were the most popular questions in that order.

Question 5 **Average mark 77%** **Response rate 97%**

(a) State the principle of conservation of momentum. (7)

Well answered. Some candidates confused the principle of conservation of momentum with the law of lever or with Newton's 1st law.

(b) A car accelerates from 10 m s^{-1} to 30 m s^{-1} in 5 seconds. What is its acceleration? (7)

Well answered.

(c) Which one of the following is the unit of power? (7)

Well answered, common wrong answer was the 'joule'.

(d) Name two methods by which heat can be transferred. (7)

Well answered.

(e) A wave motion has a frequency of 5 Hz and a wavelength of 200 m. Calculate the speed of the wave. (7)

Well answered.

(f) Infrared radiation is part of the electromagnetic spectrum. Name two other radiations that are part of the electromagnetic spectrum. (7)

Well answered.

(g) Name the electrical component represented in the diagram. (7)

Common wrong answer was the resistor.

(h) List two safety devices that are used in domestic electric circuits. (7)

Well answered. Common wrong answers included insulation, switches, and transformers.

(i) What is the photoelectric effect? (7)

Many candidates confused the photoelectric effect with thermionic emission.

(j) Name a material used as shielding in a nuclear reactor. (7)

Well answered.

Question 6 **Average mark 56%** **Response rate 68%**

- Define pressure and give the unit of pressure. (12)

  The definition of pressure was usually well answered though some candidates had ‘force per area’ or ‘on certain area’.

- Name an instrument used to measure pressure. (5)

  Well answered.

- The earth is covered with a layer of air called the atmosphere. What holds this layer of air close to the earth? (6)

  The ‘atmospheric pressure’ was often given as holding the air close to the earth.

- Describe an experiment to show that the atmosphere exerts pressure. (12)

  The experiment was usually well described by those who attempted it but was quite often omitted, and some described the Boyle’s Law apparatus.

- The type of weather we get depends on the atmospheric pressure. Describe the kind of weather we get when the atmospheric pressure is high. (6)

  The descriptions of the weather were many and varied. Not many candidates mentioned ‘calm’ or ‘settled’ weather.

- An elephant weighs 40 000 N and is standing on all four feet each of area 0.2 m^2. Calculate the pressure exerted on the ground by the elephant. (9)

  Many calculated the pressure of the elephant using the area of just one foot (0.2 m^2).

- Why would the pressure on the ground be greater if the elephant stood up on just two feet? (6)

  Poorly answered.

Question 7 **Average mark 58%** **Response rate 61%**

- Reflection and refraction can both occur to rays of light.
  What is meant by the reflection of light? State the laws of reflection of light. (15)

  Describe an experiment to demonstrate one of the laws of reflection of light. (12)

  The diagram shows a ray of light travelling from glass to air. At B the ray of light undergoes refraction. Explain what is meant by refraction. (6)

  Many candidates got reflection and refraction mixed up in both the laws and the experiment.

- What special name is given to the angle of incidence *i*, when the effect shown in the diagram occurs? (6)

  Many candidates didn't know the term 'critical angle'

- In the diagram the value of the angle *i* is 41.8^{o}. Calculate a value for the refractive index of the glass. (6)

  Many candidates could not calculate the refractive index.

- Draw a diagram to show what happens to the ray of light when the angle of incidence *i* is increased to 45^{o}. (6)

  Poorly answered.

- Give one application of the effect shown in the diagram you have drawn. (5)

  Poorly answered.

Question 8 **Average mark 60%** **Response rate 38%**

- State Ohm's Law. (9)

  Generally well answered.

- The graphs show how current (*I*) varies with potential difference (*V*) for (a) a metal, (b) a filament bulb. Which conductor obeys Ohm's law? Explain your answer. (12)

  Generally well answered.

- The circuit diagram shows a 100 Ω resistor and a thermistor connected in series with a 6 V battery. At a certain temperature the resistance of the thermistor is 500 Ω.

  Calculate

  (i) the total resistance of the circuit;

  (ii) the current flowing in the circuit;

  (iii) the potential difference across the 100 Ω resistor. (18)

  Part (i) was well answered, but many candidates scored poorly on the other calculations.

- As the thermistor is heated, what happens to

  (iv) the resistance of the circuit?

  (v) the potential difference across the 100 Ω resistor? (12)

  The calculation of the total resistance caused few problems but many candidates scored poorly on the other calculations.

- Give a use for a thermistor. (5)

  The use of the thermistor was poorly answered and many devices were given e.g. kettle, doorbell etc.

Question 9 **Average mark 53%** **Response rate 57%**

- What is a magnetic field? (6)

  Well answered.

- Draw a sketch of the magnetic field around a bar magnet. (9)

  Well answered.

- Describe an experiment to show that a current carrying conductor in a magnetic field experiences a force. List two factors that affect the size of the force on the conductor. (18)

  The experiment was well answered but many candidates confused it with experiments to show electromagnetic induction or to show a magnetic field. The two factors which affect the size of the force were well answered but the 'size' of the conductor or magnet was a common incorrect factor.

- A coil of wire is connected to a sensitive galvanometer as shown in the diagram.
  What is observed when the magnet is moved towards the coil? (6) Explain why this occurs. (6)

  This was poorly answered and many candidates gave vague answers.

- Describe what happens when the speed of the magnet is increased. (6)

  Candidates gave many vague answers.

- Give one application of this effect. (5)

  This was very poorly answered.

Question 10 Average mark 61% Response rate 57%

- The electron is one of the three main subatomic particles. Give two properties of the electron. Name another subatomic particle. (12)

  Well answered, though many candidates did not specify 'negative' charge.

- The diagram shows a simple cathode ray tube. Name the parts labelled A, B and C. (12)

  Part A of diagram was usually identified even if only as a 'coil'. Parts B and C of the diagram caused more problems and the 'cathode' and the 'anode' were often mixed up. Part C was often given as 'X and Y plates'.

- Electrons are emitted from A, accelerated across the tube and strike the screen. Explain how the electrons are emitted from A. (9)

  Many candidates did not mention 'thermionic emission'. Candidates rarely mentioned the 'current' heating the coil.

- What causes the electrons to be accelerated across the tube? (6)

  Poorly answered.

- What happens when the electrons hit the screen? (6)

  Well answered.

- How can a beam of electrons be deflected? (6)

  Poorly answered.

- Give one use of a cathode ray tube. (5)

  Well answered. Some candidates gave 'X-rays' as a use.

Question 11 **Average mark 62%** **Response rate 85%**

(a) Define energy. (7)

Well answered.

(b) What energy conversion takes place when a fuel is burnt? (7)

Well answered.

(c) Name one method of producing electricity. (7)

Well answered.

(d) Give one factor on which the potential energy of a body depends. (7)

Some candidates gave 'position' or 'food' as factors determining P.E.

(e) What type of energy is associated with wind, waves and moving water? (7)

Well answered.

(f) Give one disadvantage of non-renewable energy sources. (7)

Well answered.

(g) How does the sun produce heat and light? (7)

Many candidates gave incorrect answers such as 'radiation', 'solar panels' or 'chemical reactions'

(h) In Einstein's equation $E = mc^2$, what does c represent? (7)

Many candidates didn't know what 'c' was, some wrote c = constant.

Question 12 **Average mark 55%** **Response rate 80%**

Part (a)

- To calibrate a thermometer, a thermometric property and two fixed points are needed. What does a thermometer measure? (6)

  Well answered.

- What are the two fixed points on the Celsius scale? (6)

  Well answered.

- Explain the term thermometric property. (6)

  Well answered.

- Name the thermometric property used in a mercury thermometer. (6)

  Poorly answered, with 'mercury' 'alcohol' or 'expansion' being common wrong answers.

- Give an example of another thermometric property. (4)

  Poorly answered.

Part (b)

- What is meant by (i) diffraction, (ii) interference, of a wave? (12)

  Interference was well answered. Diffraction was not as well answered.

- In an experiment, a signal generator was connected to two loudspeakers, as shown in the diagram. Both speakers are emitting a note of the same frequency and same amplitude. A person walks along the line XY. Describe what the person hears. What does this experiment demonstrate about the nature of sound? (12)

Many candidates mentioned the Doppler effect, or variations in loudness due to distance from the speakers in their description of what was heard. Many candidates omitted the conclusion of the experiment. A few candidates mentioned the 'wave' nature of sound.

- What is meant by the amplitude of a wave? (4)

  Many candidates did not know the meaning of the amplitude of a wave and was poorly answered.

Part (c)

- The diagram shows a gold leaf electroscope. Name the parts labelled A and B. (6)

  Poorly answered.

- Give one use of an electroscope. (6)

  Well answered.

- Explain why the gold leaf diverges when a positively charged rod is brought close to the metal cap. (9)

  Poorly answered.

- The positively charged rod is held close to the electroscope and the metal cap is then earthed. Explain why the gold leaf collapses. (7)

  Poorly answered.

Part (d)

- Na-25 is a radioactive isotope of sodium. It has a half life of 1 minute. What is meant by radioactivity? (6)

  The meaning of radioactivity was often imprecise.

- Name a detector of radioactivity. (6)

  Well answered.

- Explain the term half life. (6)

  The meaning of half-life were often vague.

- What fraction of a sample of Na-25 remains after 3 minutes? (6)

  Usually well answered. A common wrong answer was 25/3.

- Give one use of a radioactive isotope. (4)

  The use was usually well answered but others had ‘energy’ as a use.

4. CONCLUSIONS

- Examiners and teacher representatives agreed that the physics examination papers were reasonable and fair. The papers gave candidates a good opportunity to apply their skills and knowledge. There was both depth and breadth to the question items. The examination papers provided a good degree of discrimination in that the more able candidates could distinguish themselves while the average candidate had sufficient scope to achieve success.

- The structure of the papers enabled candidates to select their questions and chose an appropriate range and options within the questions. Candidates had adequate time to complete the required number of questions and many candidates attempted extra questions.

- Candidates showed a good knowledge of the experiments listed in the syllabus. Most candidates scored well in Section A, but the work of less able candidates lacked detail and many gave vague or incorrect descriptions of the experiments.

- Definitions and laws were answered satisfactorily. While candidates seemed to know the laws, their understanding of applications of the laws was sometimes poor.

- Candidates scored reasonably well in the Science, Technology and Society (STS) aspects of the paper but less able candidates did not give applications when required. The full STS question seemed to be an attractive question for candidates, and candidates scored well on this question.

- Diagrams were generally used to support written answers, where appropriate. The diagrams were usually well drawn and labelled and able candidates used them to complement their explanations/descriptions.

- Units of measurement were often omitted or incorrect.

- Very few candidates used data logging methods in section A.

- Where candidates did poorly, there were three major causes: not answering enough questions, not displaying a clear understanding of physics; and not calculating correctly.

- There was a marked tendency for candidates to avoid questions on electricity.

- A significant majority of the Higher Level candidates chose to answer the question on particle physics rather than the question on applied electricity.

- Candidates who performed well in the examination showed clear comprehension of:
  - knowledge of the fundamental principles of physics
  - applications of physics to everyday life and technology
  - knowledge, derivation and application of formulae
  - logical thought and problem solving
  - mandatory and demonstration experiments
  - factual items
  - definitions
  - graphing skills.

5. RECOMMENDATIONS

- It is essential that candidates study all sections of the syllabus and that they answer the required number of questions in the examination.

- It is important that plenty of experiments and demonstrations are undertaken to make physics more engaging for candidates. Many candidates do not seem to understand scientific method, and have difficulty in data handling and in presenting results.

- Candidates need to experience a wide variety of practical and relevant situations in which they can apply their knowledge of the principles and concepts of physics.

- Candidates need to integrate their knowledge of physics with everyday experiences to enhance their understanding of the STS aspect of the syllabus.

- Candidates need to be able to express their understanding of physics concepts in language that is clear, concise and correct.

- Teachers should encourage their students to understand the principles of physics using a variety of techniques.