Public Examinations, 1935

EXAMINER'S REPORTS.

By permission of the Department of Education, the reports of the examiners in Science subjects in the recent Leaving Certificate and Intermediate Certificate examinations will be published in this magazine, so as to make them available to teachers and students during the current year, prior to the publication of the official handbook of the Department.

In this issue the reports on the Physics papers are printed ; it was hoped that others might also be included, but they are not yet available, and so should appear in the next issue.

LEAVING CERTIFICATE PHYSICS.

GENERAL.

The standard of the candidates presenting themselves was generally satisfactory, the average of passes being brought down by a few weaker centres. Necessarily, a deeper understanding of the subject is required from candidates for this examination than that for the Intermediate Certificate, and not merely extended knowledge. In setting the examination, attention is given to the provision of such a standard and distribution of questions that a student prepared merely to get an excellent mark at the Intermediate Examination should not be able to secure even a lower standard pass at this Leaving Certificate Examination. The papers, consequently, may be criticised as being difficult ; they are difficult in that they require candidates to understand the principles of the subject and to be able to think originally, but are set with a very wide choice, within the approved syllabus, and that they are within the range of all who have properly prepared themselves is shown by the very satisfactory results.

Candidates are recommended to help themselves by learning simple methods of calculating within the accuracy required : *particular attention is drawn to the relations* (i) $\frac{1}{1+a}=1-a$ (a use of this would have saved much time in several questions in this paper ; (ii) $(1+a)(1+b)=1+a+b$; (iii) $(1+a)^n=1+na$, a and b being *small* values in each case. Candidates are also permitted to use tables of logarithms and of trigonometrical tables, and slide rules, provided that they work to the accuracy required by the problem.

Candidates must again be warned that definitions must be precise and complete : carelessness and omissions are fatal in many cases ; they are again reminded to practice sorting out their facts in descriptive questions, putting them together then briefly and correctly in the reply. Continued practice in expressing themselves clearly, briefly, and yet correctly and as fully as time and knowledge permit, will be of benefit to them, not only in answering examination questions in Physics, but in many other ways.

PASS PAPER.

Question I.—(*a*) Define the following : dyne, poundal, erg, foot-poundal, joule, pound weight. Calculate the relation between a pound weight and a dyne (1 pound=454 grms. ; 1 inch=$2\cdot54$ cms.). (*b*) A mortar fires a projectile of mass 150 pds. with a muzzle velocity of 500 ft. sec.$^{-1}$, the instantaneous direction of flight being at 45° with the horizontal, from a train travelling on a straight level track at 60 miles hour^{-1}. It is desired to fire a bomb from the mortar so that it may fall on to a station through which the train has just passed. How long a time should elapse after leaving the station before the mortar is fired ? What is the kinetic energy of the bomb on leaving the mortar ?

The definitions were generally satisfactory. The problem was generally badly done, or well done on wrongly-taken data.

The *muzzle velocity*=500 ft. sec.$^{-1}$, and the instantaneous direction of motion of the projectile is 45°. The resultant velocity in magnitude and direction is at 45° to the horizontal, and is compounded vectorially (*graphically* or mathematically) of 88 ft. sec.$^{-1}$ in the direction of the train's motion, and 500 ft. sec.$^{-1}$ in an unknown direction. The bomb therefore travels (relative to the ground) at an angle of 45° and a velocity of 434 ft. sec.$^{-1}$.

$\therefore$ Time of flight$=19\cdot2$ secs., and range on horizontal=5,900 ft.

$\therefore$ Time since train left station$=\frac{5900}{88}=67$ secs.

The kinetic energy, measured relative to an earth at rest, is $\frac{1}{2}\times 150\,(434)^2 = 14\cdot 1\times 10^6$ ft. pdls. Liberal allowance in marking was made for correct work in sections. Candidates need not have selected this question (one out of the first three was compulsory), but it discloses that they require to pay more attention to relative motion.

Question II.—Define a simple harmonic motion. Show that a mass oscillating in a vertical straight line at the end of a spring is executing a S.H.M., and calculate the period of its oscillation, the spring being of negligible mass.

It is found that the addition of a load of 20 grms. to the free end of a light spring hanging vertically pulls down that end 4 cms. What is the period of oscillation of this vertical spring with that mass attached ?

This required the definition of S.H.M., and then the proof that in the case given $F\alpha d$, then the derivation of $T = 2\pi\sqrt{\frac{m}{\mu}}$.

In the problem $\mu = 4{,}900$ dyne cm.$^{-1}$, and $T = 0\cdot 40$ sec. The question was well answered.

Question III.—An empty rubber balloon has a mass of $5\cdot 0$ grms. It is inflated with air until its internal volume is 1,000 c.c., and is then kept immersed in water at 20° C. by having a piece of copper attached to it by copper wire, the copper also being completely immersed. What mass of copper must be attached ?

(Density of copper $= 8\cdot 9$ grm. cm.$^{-3}$; density of air in balloon at 20° C. $= 1\cdot 24$ grm. litre^{-1} ; density of water at 20° C. $= 0\cdot 998$ grm. cm.$^{-3}$; density of rubber $= 0\cdot 95$ grm. cm.$^{-3}$.)

This was surprisingly badly attempted ; it was a simple question for the Leaving Certificate, and was included because one question from the first three was compulsory. Usually solved thus

$$\downarrow 5 + 1\cdot 24 + M = \uparrow \frac{M}{8\cdot 9}\times 0\cdot 998 + 1000\times 0\cdot 998 + \frac{5}{0\cdot 95}\times 0\cdot 998.$$

$$\therefore\ M = 1{,}122 \text{ grms.}$$

(Some students took the density of water as unity, stating that the density of the copper was only given to 1 in 90, and of rubber to 1 in 95 ; they were correct, and saved themselves unnecessary work.)

Question IV.—State Dalton's laws of partial pressure.

A hollow glass sphere has an internal volume of 500 c.c. at 35° C. and contains $0\cdot 250$ grm. of oxygen and $0\cdot 230$ grm. of nitrogen, saturated with water vapour at that temperature. What is the internal pressure ?

The sphere is now cooled down to 0° C., water condensing on its inside surface. What mass of water thus condenses, and what is the new internal pressure ? (Neglect change in volume of sphere and volume occupied by condensed water. Molecular weights of oxygen and nitrogen are 32 and 28 respectively ; S.V.P. water at 0° C. and 35° C. are $4\cdot 58$ mm. and $41\cdot 85$ mm. respectively ; masses of water vapour per cubic metre of saturated space at 0° C. and 35° C. are $4\cdot 85$ grms. and $39\cdot 23$ grms. respectively. The density of hydrogen at S.T.P. is 9×10^{-5} grm. cm.$^{-3}$.)

The laws were generally correctly stated. The problem was *not* well attempted, far too many candidates making the bad mistake of supposing that the water vapour followed Boyle's law.

$$\left.\begin{array}{l}\text{At } 35^\circ \text{ C., Oxygen pressure} = 298 \text{ mm.}\\ \text{Nitrogen pressure} = 313 \text{ mm.}\\ \text{S.V.P. pressure} = 42 \text{ mm.}\end{array}\right\}\ \text{Total Pressure 653 mm.}$$

Mass of water vapour condensing at 0° C. $= \dfrac{(39\cdot 23 - 4\cdot 85)\ 500.}{10^6}$
(Most got this wrong.)

$= 0\cdot 017$ grm.

$$\left.\begin{array}{l}\text{At } 0^\circ \text{ C. (Oxygen + Nitrogen) pressure} = 542 \text{ mm.}\\ \text{S.V.P.} = 5 \text{ mm.}\end{array}\right\}\ \text{Total 547 mm.}$$

Question V.—Define the following : gramme-calorie, British thermal unit, specific heat.

Calculate the minimum cost of having a hot bath when the water is heated by a gas bath-heater burning gas of calorific value 550 B.T.U. per cubic foot at a cost of $0\cdot 060$ penny per cubic foot, given the following information : Water equivalent of bath, 25 pounds ; temperature of cold water supply and of bath water, 40° F. and 105° F. respectively ; initial temperature of bath, 45° F. ; volume of water used, 9 cubic feet ; density of water, $62\cdot 5$ pounds ft.$^{-3}$.

Explain why it would actually cost more than this minimum amount.

Definitions were generally correct. The problem was short and simple, and gave many students opportunities for careless mistakes.

$$\text{Cost}=\frac{25(105-45)+9\times 62\tfrac{1}{2}(105-40)}{550}\times 0\cdot 060=4\cdot 15 \text{ pence.}$$

Answers were interesting ; many were in the thousand pound class, the record being £4,702. These foolish candidates, instead of looking for the error, went on to explain why this was a " minimum amount ". Explanations as to the methods of heat loss (including latent heat of vaporisation, hot gases, convection, etc.) were generally good. Some expressed surprise that the bath water for a " hot bath " should only be 105° F. It might surprise them to sit in a bath at 110° F.

Question VI.—Two chocolate-coated ice-cream bars, one wrapped in tin foil and one uncovered (initially at the same temperature), are placed on a plate (i) in a closed ice chest, (ii) in the sunlight. State what you consider to be the order of their melting in each case, *giving the reasoning* leading you to your conclusions.

This was the popular question amongst the weakest people, and was very poorly attempted. Very many took the ice chest as being colder than the ice-cream blocks, and yet caused the blocks to melt by " radiating cold ". Briefly : Two chocolate-coated ice-cream blocks on plates in ice chest ; both are surrounded by gases at the same temperature, both radiate, and both receive radiations ; colder than their surroundings, so receive heat more rapidly than radiate it ; chocolate surface (dark) better absorber than " silver " surface, so unwrapped bar melts more rapidly. In sunlight, same conditions obtain, but temperature difference greater now, one radiator (sun) being high temperature body ; so again unwrapped bar melts first, though both melt more rapidly than in chest. $\{E=\sigma(\theta_1{}^4-\theta_2{}^4).\}$ In ice chest, the difference *decreases* as chocolate rises in temperature, because it then has a less temperature difference from its surroundings. Tinfoil wrapping would not affect subject materially so far as conduction and convection effects are concerned ; it is thin, and a good conductor.

Some candidates took the inside of ice chests as being at absolute zero. Few gave a logical discussion.

Question VII.—(*a*) What is a simple harmonic progressive wave ? Derive the equation $v=n\lambda$ for a progressive wave. (*b*) State the conditions necessary for the formation of stationary waves. What are the nodes, and how far apart are they spaced ? (*c*) An open pipe is in resonance with a particular tuning-fork when its length is 58 cms., and also when cut to 28 cms. Taking the velocity of sound as being 33,000 cms. sec.$^{-1}$, calculate the frequency of the fork and the end correction for the tube.

This was a conventional type of question, and well attempted.

$$\frac{\lambda}{2}-2x=28, \text{ and } \lambda-2x=58. \qquad \therefore\ \lambda=60 \text{ cms., and } N=550 \text{ per sec.}$$

$$\therefore\ 2x=2 \text{ cms.}=\text{end correction (or 1 cm. at each end).}$$

Question VIII.—State the laws of refraction. The external field of view of a fish is contained within a cone of rays in the water leading to the fish's eye. Calculate the value of the angle of this cone, the refractive index of the water being $1\cdot 33$. Discuss how this is affected by placing on the surface of the water a plate of glass of refractive index $1\cdot 66$. Draw, to scale, the path of the limiting rays of the cone in the plane of your paper in each of these cases.

The laws were generally correctly stated, and the first part of the problem (old) was answered correctly. Most candidates failed completely in the last part ; the drawing should have helped them, but they endeavoured wrongly to adjust their diagram to their wrong reasoning. The fish-eye view is *not* affected by the plate of glass on top. Marking the angles with the normal progressively in air, in glass, in water as (1), (2), (3), (4), then $\frac{\sin(1)}{\sin(2)}=1\cdot 66$, and $\frac{\sin(3)}{\sin(4)}=\frac{1\cdot 33}{1\cdot 66}$. $\therefore\ \frac{\sin(2)}{\sin(4)}=\frac{1\cdot 33}{1\cdot 66}$. (2)=(3), and also $\sin(1)=1$. $\therefore\ \sin(4)=\frac{1}{1\cdot 33}$ as in first case.

Question IX.—Describe, with full experimental and theoretical detail, some quantitative experiment which you personally have performed to determine any ONE of the following : (i) the frequencies of the notes emitted by stretched strings ; (ii) a wave length of light ; (iii) the focal length of a lens.

A general question such as this requires careful answering ; many candidates were far too verbose without giving the information required ; (i) it must be a *quantitative* experiment (many missed that) ; (ii) the experimental detail is demanded ; (iii) necessary supporting theory is required. Answers were awarded the complete range from full marks to nothing; most candidates of pass standard get about 70% for such a question.

Question X.—(*a*) Derive the equation for the magnetic intensity at the centre of a circular coil of wire carrying a current, and show how the electro-magnetic units of current, quantity, potential difference and resistance are derived therefrom.

(*b*) A linear conductor of length 20 cms. is moved with a velocity of 30 cms. sec.$^{-1}$ at right angles to its length so as to cut normally the lines of force of a field of strength 500 gauss. What is the value in volts of the induced e.m.f.?

The first part is book work, and being fundamentally important, has often been set in some form; generally well attempted, or very badly. The problem also was well attempted.

$$E=\frac{dN}{dt}=\frac{500\times 20\times 30}{1\times 10^{8}}\text{ volts}=3\times 10^{-3}\text{ volts.}$$

Question XI.—(*a*) State Faraday's laws of electrolysis. Define the following: Avogadro's number, the Faraday, electro-chemical equivalent, gramme equivalent, gramme molecule. (*b*) Copper being divalent and of atomic weight 63·6, calculate the mass of copper deposited in a voltameter by a current of 2·00 ampères passed for 20 minutes. (The Faraday is 96,500 coulombs/grm. equivalent.)

What volume of hydrogen, at standard temperature and pressure, would be liberated in a voltameter in series with this? (A gramme molecule of gas occupies 22·4 litres at S.T.P.)

The definitions were satisfactorily answered, as was the statement of Faraday's laws. The first part of the problem was well attempted, but far too many went astray in the second part.

$$M_{\mathrm{Cu}}=\frac{63\cdot 6}{2}\times\frac{2\times 20\times 60}{96{,}500}=0\cdot 79\text{ grm.}$$

$$\therefore\ M_{\mathrm{H}}=\frac{0\cdot 79\times 2}{63\cdot 6}=25\times 10^{-3}\text{ grm.}\quad \therefore\ V_{\mathrm{H}}\text{ (S.T.P.)}=11\cdot 2\times 25\text{ c.c.}$$
$$=280\text{ c.c.}$$

Question XII.—Describe, with full experimental and theoretical detail, some quantitative experiment which you personally have performed to determine any ONE of the following: (i) the resistance of a conductor; (ii) the e.m.f. of a cell; (iii) the value of Joule's equivalent by an electrical method.

See the discussion of Question IX; it applies also to this question.

HONOURS PAPER.

Question I.—A stone of mass 5 pounds is whirled round at the end of a string so as to describe a vertical circle of radius 2 feet, making 20 revolutions per minute; if the angular velocity be uniform throughout, determine the tension (magnitude and direction) in the string when the stone is (i) at the top, and (ii) at the bottom of its path, and (iii) at a level halfway between these.

Considering methods by which the stone might be whirled, discuss the probability of the angular velocity being constant.

If it were possible for the angular velocity to be constant throughout, $\omega=\frac{2\pi}{3}$, and $\omega^2 r=\left(\frac{2\pi}{3}\right)^2\times 2=8\cdot 8$ ft. sec.$^{-1}$.

$\therefore$ (i) At top $T=m\omega^2 r-mg=5(8\cdot 8-32\cdot 2)=-117$ pdls.

(ii) At bottom, $T=5(8\cdot 8+32\cdot 2)=205$ pdls.

(iii) Halfway up, $T=5\times 8\cdot 8=44$ pdls.

Probability of constant angular velocity: This is not possible, (*a*) because in every position of the body except (i) and (ii) there is a tangential force producing a tangential acceleration, (*b*) on account of the "negative tension" required in case (i). It could only rotate in part of the circumference of the circle until T approached zero, and the tension would have to be varied by suitable means.

This question was very well attempted.

Question II.—A load of 20 Kgs. hangs vertically from a light free pulley, which in turn is supported by steel wire of cross-section 1 sq. mm. which passes over a fixed pulley; the system is kept in equilibrium by a load of M Kgs. attached to the free end of the wire. The total length of the wire is

2 metres, the Young's modulus of the wire is 20×10^{11} dyne cm.$^{-2}$, and it is found to have been extended by 2 mm. Calculate the value of M, and of the angle made with the horizontal by the wire supporting the free pulley. The system being in equilibrium under the loading given above, the temperature increases.

Discuss qualitatively what changes may be expected in the angle of inclination, and in the height of the two masses.

In the paper the student was aided by the addition of a diagram (omitted here). The first part was well attempted, the second part generally imperfectly and incompletely.

$$20\times10^{11}=\frac{F\times200}{2\times10^{-1}\times1\times10^{-2}}.\quad\therefore\ F=20\cdot4\text{ Kg. wgt.}$$

$$F\sin\alpha=10\text{ Kg. wgt.}\quad\therefore\ \operatorname{Sin}\alpha=\frac{10}{20\cdot4}=0\cdot490.$$

$$\therefore\ \alpha\text{ (angle of wire to horizontal)}=29^\circ\ 21''.$$

Temperature Effect. Masses do not alter, hence α *always constant.* Change in Y.M. gives change in e, and hence (α constant) the 20·4 Kg. drops with rise in temperature, 20 Kg. stays at rest. Change in length of wire causes 20·4 Kg. mass to drop with rise in temperature, 20 Kg. stationary. Change in distance apart of supports : As α is constant, with rise in temperature the 20 Kg. must drop, and the 20·4 Kg. mass rise (this last possible change was nearly always overlooked).

Question III.—Derive an equation giving the excess pressure inside a soap bubble. A soap bubble is blown on a bubble pipe ; then, without detaching it, another bubble is blown within, but separate from the first (the bubbles may be taken as spherical). The outer bubble having a radius of 3 cms., and the inner a radius of 1 cm., calculate the excess pressure within the inner bubble above atmospheric pressure when the surface tension is 30 dyne cm.$^{-1}$.

Discuss qualitatively the effect of change in temperature on the size of the bubbles and on the internal pressures, no gas entering or escaping.

The equation was successfully derived.

$$P_2=\frac{4S}{R}+\frac{4S}{R_2}=\frac{4\times30}{3}+\frac{4\times30}{1}=160\text{ dyne cm.}^{-2}.$$

Temperature Effect. With rise in temperature, S decreases, hence P_1 and P_2 decrease ; but the gas mass enclosed is constant, so (from this effect) the volume of both bubbles increases. Also, the K.E. of the molecules increases, thus internal pressure increases, and hence bubbles expand. (Both effects tend to cause bubbles to expand.)

The problem and the discussion were either well done, or else very badly.

Question IV.—Show that the energy required to raise the temperature of a gramme-molecule of a monatomic gas through one centigrade degree is 3 calories, the volume being constant.

Argon being a monatomic gas, specific heat at constant volume 0·075, calculate its atomic weight.

(The density of hydrogen at S.T.P. is 9×10^{-5} grm. cm.$^{-3}$; the universal gas constant is 8·4 joules per grm. mol. per cent. deg. ; J is 4·2 joules per calorie.)

The gas is monatomic, so on heating all energy goes to K.E. translation.

E = K.E. translation per grm. mol. $=\frac{1}{2}Nm\bar{V}^2$ (when $N=nv$).

Also $p=\frac{1}{3}nm\bar{V}^2$, so $pv=\frac{1}{3}nmv\bar{V}^2=\frac{1}{3}Nm\bar{V}^2$.

$$\therefore\ E=\tfrac{1}{2}Nm\bar{V}^2=\frac{3}{2}pv=\frac{3}{2}RT.$$

$\therefore$ Change in E for unit temperature change $=\frac{3}{2}R=E^1$.

$$R=\frac{8\cdot4}{4\cdot2}=2\text{ cals. deg.}^{-1}\text{ grm. mol.}^{-1}.\quad\therefore\ E^1=3\text{ cals./grm. mol.}$$

Thence $C_V=\frac{3}{M}$. So $0\cdot075=\frac{3}{M}$. $\therefore\ M=40$ grms.

(M being mass of grm. molecule.)

$\therefore$ Atomic weight is 40.

This question was well done by those competent to attempt it.

Question V.—Draw, to scale, the isothermals for one gramme of hydrogen at (i) 0° C., (ii) 100° C. between pressures of one and two atmospheres. Consider the form of these lines in regions at very great pressure and discuss whether they would meet if the pressure range were indefinitely extended.

Draw the isothermal at 100° C. for one gramme of water vapour and water in contact (600 grms. of water vapour saturate a cubic metre at 100° C.).

This was not a difficult question, requiring merely a knowledge of gas and vapour isothermals; it was not nearly so well attempted as it should have been.

The limits are:

1 grm. hydrogen occupies $11 \cdot 2$ litres at S.T.P.

1 „ „ „ $5 \cdot 6$ „ „ S.T. and 2 atmos.

1 „ „ „ $11 \cdot 2 \times \frac{373}{273} = 15 \cdot 3$ litres at S.P. and 100° C.

1 „ „ „ $7 \cdot 65$ litres at 2 atmos. and 100° C.

To suitable scale, the two isothermals (PV=const.) are drawn within these limits.

With big increases in pressure the molecules are crowded, and Boyle's law does not apply; although it is well above critical temperature (−234° C.), the gas *tends* to the liquid coniditon, and the lines tend towards straight lines; these would then lie close together, but only actually meet if indefinitely extended.

With very low pressures Boyle's law applies, the curves approach closely (being asymptotic to vol. axis) and $V = \infty$ when $P = O$.

The isothermal at 100° C. in the last case (water vapour) is a straight line parallel to the volume axis. At 100° C. S.V.P.=760 mm., the volume *saturated* by vapour at 100° C. is $\frac{10^6}{600} = 1{,}666$ c.c., and the volume if all compressed to water is approximately 1 c.c. (As the line from 1 to 1,666 c.c. would be hard to show to scale, it is best drawn broken above a similarly broken axis, thus —— . . . ——)

Question VI.—Prove that the velocity of transmission of a transverse wave along a stretched string may be expressed by an equation $v = \sqrt{\frac{F}{\mu}}$. A steel wire of mass 2 grms. and length 50 cms. between supports is stretched so as to give a note of frequency 500 per second; it gives 5 beats per second when sounding at the same time as an adjacent wire of the same material and cross section, but of length 60 cms. What is the difference in the tensions in the wires? Describe any simple experiment by which may be determined which string gives the note of higher frequency.

This was generally well attempted, though in the problems nearly all failed to notice that there were two possible answers.

$$500 = \frac{1}{100}\sqrt{\left\{\frac{F_1 \times 50}{2}\right\}}. \quad \therefore F_1 = 10^8 \text{ dynes.}$$

$$\text{or } \left.\begin{matrix}505\\495\end{matrix}\right\} = \frac{1}{120}\sqrt{\left\{\frac{F_2 \times 50}{2}\right\}}. \quad \therefore F_2 = 1 \cdot 41 \times 10^8 \text{ or } 1 \cdot 47 \times 10^7 \text{ dynes.}$$

$$\therefore F_1 \sim F_2 = (10)^8 \sim (1 \cdot 41 \times 10^8 \text{ or } 1 \cdot 47 \times 10^7) \text{ dynes.}$$

Test for higher frequency: tighten string; if beats increase, that was the h.f. string.

Question VII.—Use Huygen's principle to discuss the formation of line spectra by means of a diffraction grating, illustrating your reply with neat diagrams. A plane silver surface, ruled with 5,000 lines to the centimetre, is employed to form a reflection spectrum of light of wave length 5,900 Å.U. What will be the angular separation between the 1st and 2nd order lines, the incidence being normal? The coefficient of linear expansion of silver being 19×10^{-6} per cent. deg., calculate the effect on the above separation of a change in temperature of 30 cent. deg.

The index of refraction (μ) for air at S.T.P. for this line being $1 \cdot 0002918$, and the relation between μ and ρ (density of gas) being given by the equation $\frac{\mu - 1}{\rho}$ constant, justify the disregarding of the variation of the value of μ in solving this question.

This question was not well attempted, except in the first part, which was advanced book work. In the problem, most who attempted it refused to consider it as a reflection grating; no one dealt with the last part fully.

$\lambda=\frac{d}{n}(\sin\theta_n-\sin r)$. Here $r=0$ (normal incidence).

$\therefore\ 59\times10^{-6}=\frac{1}{5000}\sin\theta.\quad\therefore\ \text{Sin}\ \theta=295\times10^{-3}$ and $\sin\theta_2-590\times10^{-3}$.

$\therefore\ \theta_1=17°\ 10'$, and $\theta_2=36°\ 9'$. $\therefore\ \theta_2-\theta_1=18°\ 59'$.

Temperature Effect. d increases by 57×10^{-5} of original value for rise of 30° C., so $\sin\theta_1$ and $\sin\theta_2$ each decrease by 57×10^{-5} of their value, giving a change of $16\cdot8\times10^{-5}$ and $33\cdot4\times10^{-5}$ respectively, i.e. a change of approx. ½ minute in θ_1 and 1 minute in θ_2, giving a change of about ½ minute in the separation.

ρ increases by $\frac{30}{273}$ of value, so $(\mu-1)$ increases by $\frac{30}{273}$ of its value, giving a change in μ of approx. 3×10^{-5}; the change in λ (59×10^{-6} cm.) is proportional to the change in μ; hence this change in λ is very small compared with the change in d, and may be neglected.

Question VIII.—The refractive index of fused silica is $1\cdot46$. It is found that for a certain angle of incidence light reflected from a polished surface of this material is plane polarised. Explain with full detail of experimental arrangement and procedure how you would determine the value of this angle.

Calculate the value you would expect to obtain. What is the velocity of light in the material, which is isotropic? (The velocity of light in air is 186,000 miles sec.$^{-1}$).

This question was quite well answered, the replies both to the experimental portion and to the problems being generally satisfactory.

$$i=\tan^{-1}1\cdot46=55°\ 36.\quad V_2=\frac{1}{1\cdot46}\times186{,}000=127{,}000\text{ miles sec.}^{-1}.$$

Question IX.—Describe, with full theoretical and practical details, how you would determine the elements of the earth's magnetic field at a given position, it being desired to obtain H to an order of accuracy of 1 in 100, and the angular quantities to within ½°.

This question also was generally well attempted, many of the answers being very good, showing that the experimental side of the work had been conscientiously prepared.

Question X.—A copper hoop of diameter 80 cms. has a resistance of $0\cdot10$ ohm, and is held with its plane vertical in the magnetic meridian and then allowed to fall over to the east. The horizontal component of the earth's field being $0\cdot25$ gauss and the dip 65° south, calculate the quantity of electricity which will flow round the hoop whilst it is falling.

State clearly in what direction the current will flow in the circle, and describe the energy transformation.

This question was not popular, but was done well by most who attempted it.

$$Q=\frac{N}{10^8R}=\frac{H\ \tan\varphi\times\text{area of hoop}}{10^8R}$$

$$=\frac{0\cdot25\times2\cdot14\times\pi\times1600}{10^8\times10^{-1}}=26\cdot9\times10^{-5}\text{ coulomb.}$$

Current flows from S. to N. in part of hoop in contact with ground.

P.E. = Elec. Energy + K.E. + Heat = Heat Energy.

Question XI.—A coil of 1,500 turns is wound on a wooden ring, the mean perimeter of which is 60 cms., the coil thus being an endless solenoid of that length. The mean cross sectional area of the solenoid is 16 cms. What is the value, in henries, of the self-inductance of the circuit? On this circuit is wound a secondary solenoid of 2,000 turns, the change in perimeter and cross section being negligible; what is the coefficient of mutual induction between the two circuits? Discuss the effect of employing an iron core in problems involving self or mutual induction.

$$L=\frac{4\pi N^2A}{10^9}=\frac{4\pi(1500)^2\times16}{10^9\times60}=7\cdot5\times10^{-3}\text{ henry.}$$

$$M=\frac{4\pi N_1AN_2}{10^9l}=\frac{4\pi\times1500\times16\times2000}{10^9\times60}=1\cdot00\times10^{-2}\text{ henry.}$$

The problems were satisfactorily attempted ; the discussions (on the effects of iron cores) were also, usually, quite good, candidates employing their knowledge of the effects of iron cores in machines.

NOTE-BOOKS.

The standard of practical work disclosed by the note-books, and the method of recording the work in the books continues to be satisfactory from nearly all schools.

Some of the smaller schools clearly have not been able to spend as much on apparatus as have the larger and earlier established schools, but some of these, by judicious choice of simple experiments involving little and cheap apparatus, have established a fair course.

It might be worth the consideration of groups of closely associated smaller private schools to group together to purchase some special sets of more expensive apparatus between them, to use in rotation. From some few schools, non-State, the number of experiments submitted continues to be small, and the standard that of the Intermediate Certificate ; this counts particularly against candidates for Honours, the standard and variety of whose practical experiments is expected to be well above that of the ordinary pass student.

Candidates are asked to make sure that every experiment is dated and initialled by the class supervisor, and that the necessary certificate is signed by the responsible person and bears the number of the candidate.

Supervision is generally very good ; order of accuracy still requires to be watched carefully—students should feel that it is quite wrong to give the value, of a latent heat of fusion, for example, as "$L=78\cdot43$ cals./grm.".

Further, the book is the candidate's work record, and property ; the master is not responsible for *correcting* the work, but only for indicating errors and corrections that require to be made ; in some few cases the work is half the master's, performed in red ink, there being nothing to indicate that the student has even noticed his master's efforts on his behalf.

INTERMEDIATE CERTIFICATE PHYSICS.

The papers presented by some centres were very good, practically all candidates passing, and from certain centres nearly all candidates secured an "A" pass. From other centres the papers were very bad, whole groups repeating the same misstatements, or falling into the same errors. On an average, the results are satisfactory, but the examiners would be glad to see those candidates from bad centres given the same chances as their more fortunate fellows. For example, from one centre practically all gave the wrong and peculiar statement of Archimedes' principle (Question III) as "Archimedes' principle states that if a body be immersed or partly immersed in a fluid, the upthrust is equal to the downthrust". Certain other centres have the statement that "the upthrust is equal to the downthrust", and proceed to do strange things with it.

Another centre says ". . . it loses weight by the amount of water displaced", consistently.

Question I.—Explain, with full experimental and theoretical detail, how you would determine the density of mercury. Illustrate your reply by using probable values for the quantities measured.

Many candidates here were guilty of pouring some mercury into the scale pans and of then pouring the weighed amount into a burette. Very many others took a copper ball, and by "weighing it in air and then weighing it in mercury" found the "loss in weight". Copper floats on mercury—the densities are given at the head of the paper as $8\cdot9$ grm. cm.$^{-3}$ and $13\cdot6$ grm. cm.$^{-3}$ respectively—and there is risk of amalgamation. Some employed objects which were said to sink, and gave figures. Calculations showed that the density of this sunken object was, frequently, less than that of the mercury in which it sank. Many, also, gave good and careful descriptions of an experiment satisfactorily carried out with a density-bottle, and ran a carefully measured volume (reasonable) into a weighed beaker, which was re-weighed. Many got absurd values, though the value was given at the top of the paper.

Question II.—Define density and relative density. In a Hare's apparatus, the two vertical columns are of sulphuric acid, density $1\cdot82$ grm. cm.$^{-3}$, and oil, density $0\cdot91$ grm. cm.$^{-3}$. The height of the oil column above its external level is $20\cdot0$ cms., the atmospheric pressure being 760 mm. Calculate the air pressure above the oil and acid and the height of the acid column.

Too many define density wrongly as the "weight of 1 c.c.". Several from another centre had "density may be defined as the tightness with which the particles (molecules) are packed together".

This is quite wrong—the density of a uniform body is the relation between its mass and the volume it occupies, expressed in short as the mass per unit volume ; and it is *not* " the weight of 1 c.c.". This question was generally well attempted by those who knew what was Hare's apparatus. There is still a wrong idea that equal and uniform tubes are required.

Question III.—State Archimedes' principle. (*a*) A man has a volume of 3 cubic feet. What is the upthrust on him due to displaced air ? (*b*) A copper sphere of radius 5 cms. is submerged to a depth of 30 feet in water open to the atmosphere. What is the pressure on the sphere, and what is its apparent weight ? (The density of the water may be taken as one gramme per c.c., and atmospheric pressure 760 mm.)

Two misstatements of Archimedes' principle are given in the introduction ; their variation is great. Candidates still use " amount " variously for volume, weight, mass, or without knowing what they mean. It is not the first time that candidates have been asked to state Archimedes' principle, and it is regretted that big groups still state it, not only incompletely, but wrongly. The candidates who stated the principle as " the upthrust is equal to the downthrust " frequently got the problem right, by disregarding their own statements ; but most of them were wrong.

Question IV.—(*a*) What is meant by the following : a scale of temperatures ; upper and lower fixed points ?

(*b*) A metal sphere, of radius 2 inches at 20° C., is heated to 200° C. ; its diameter is now found to have increased by $\frac{1}{100}$th inch. What is the coefficient of cubical expansion of the metal ?

Definitions of upper and lower fixed points were generally correct, but in most cases no meaning was given for a scale of temperatures. The problem (similar to that in the Elementary Science paper, but requiring the extra knowledge that $\beta=3\alpha$) was generally satisfactorily attempted.

Question V.—State the laws of Boyle and of Charles.

The volume of a given mass of gas is $1\cdot5$ litres at 0° C. and 765 mm. When heated to 91° C. and at a pressure of 750 mm., its volume has increased by 540 c.c. What is the coefficient of cubical expansion of the gas at constant pressure ?

The definitions were generally correctly given, though the usual carelessness led to the omission of essentials such as the " pressure constant " or " temperature constant " condition for Charles' and Boyle's law respectively. Some centres have introduced a dangerous and wrong " improvement "—they define the laws in terms of " dry gas ". Gas is quite sufficient ; as they will learn later on in partial pressure experiments, the gas laws hold for the *gas* present whether it be mixed with water vapour or not ; and by definition, a gas is not itself a vapour.

The problem was generally satisfactorily attempted by the good candidates, very badly by the weak ones. It was slightly unusual, being the reverse of the type. There were several good simple methods used, *e.g.* $\frac{P_1V_1}{x+t_1}=\frac{P_2V_2}{x+t_2}$, whence $x=272$ and $\beta=\frac{1}{x}=\frac{1}{272}$. Some found the volume at 91° C. and 765 mm. (pressure unchanged), thus the change in volume of $1\frac{1}{2}$ litres at constant pressure for a change in temperature of 91 cent. deg., whence β which equalled $\frac{1}{272}$.

Question VI.—(*a*) Define the following : calorie, British thermal unit, latent heat of fusion. (*b*) In an experiment to determine the latent heat of vaporisation of ethyl alcohol, $2\cdot51$ grms. of the alcohol vapour, from the liquid boiling at 78° C., are condensed in 200 grms. of alcohol at $5°\cdot0$ C. contained in a calorimeter of water equivalent to 12 grms. The temperature of the mixture rises to $10°\cdot$ C. What is the value of the latent heat of vaporisation ?

The definitions were generally correct ; candidates must remember that latent heat of fusion does not apply only to ice, and is defined in terms of unit mass of the substance concerned, and that no temperature change is involved. The problem was generally satisfactorily attempted. ($L=204$ cals. grm.$^{-1}$.)

Question VII.—Define velocity, acceleration, force, energy, and power. A boy catches a ball of mass 360 grms. moving at 1,200 cms. sec.$^{-1}$, and brings it to rest in $\frac{1}{10}$th second by letting the hand holding it move back in a straight line. What is the average retardation of the ball, and what average power is expended on the boy bringing it to rest ?

Generally well attempted. ($a = -12{,}000$ cms. sec.$^{-2}$; power$=\frac{W}{T}=\frac{\text{K.E. change}}{t}=295$ watts.)

Question VIII.—(*a*) State and discuss Newton's three laws of motion, giving one example of each, those of the second and third laws being quantitative. (*b*) Three forks are stuck into an orange, spaced 120° apart around a circumference. It is then found that the orange can be balanced easily upon a pencil point without penetration. Illustrate this clearly by a diagram, and discuss the equilibrium conditions.

Being mainly descriptive, this was attempted by most of the weak candidates, and was very badly done. The statements of Newton's laws were generally not only incomplete but wrong, and quantitative examples were omitted. Many showed signs of attempts to memorise something heard without being understood ; for example, several wrote " The rate *or* change of momentum equals . . .".

In part (*b*) most efforts were absurd, few even getting a condition of unstable equilibrium ; what is required is that the c.g. of the system " forks and orange " should be below the point of contact of pencil point and orange ; the simplest method is to stick the forks in spaced 120° apart round a horizontal circle on the orange, sloping down so that the handles are below the pencil point. The discussions were generally merely discursive and silly.

Question IX.—State the laws of summation of vector quantities.

Four coplanar forces of 20, 30, 40 and 50 pounds weight act at a point and make angles of 30°, 60°, 90° and 120° respectively with a given direction. What is the magnitude of the equilibrant and what its direction ?

This was generally well answered, though very many gave the resultant and not the equilibrant ; many also omitted the direction. The graphical method was most favoured, though many did it correctly mathematically (resolving in x and y directions, and compounding x and y algebraic sums vectorially).

Question X.—(*a*) Discuss the nature of sound, giving what information you can of quantitative value. (*b*) What is meant by resonance ? Calculate the frequency of the tone with which a " closed " pipe of length 30 cms. is fundamentally in resonance.

Answered well by some students, very badly by many. Information of quantitative value expected was (i) Velocity in air about 33,000 cms. sec.$^{-1}$; (ii) audible frequency range about 30 to 30,000 per sec. ; (iii) ear sensitive to amplitudes as low as 10^{-8} cms. Further information might have included effect on velocity of temperature (in air and other gases, proportional to square root of absolute temperature), and relative velocities in solids ; everything was *not* required, but few gave *any* quantitative information. Part (*b*) was answered well by the good candidates (from good centres) ; many, as usual, spoilt their work by carelessness—what could it be but carelessness that would cause a candidate to write " when two vibrating bodies have the same frequency they are both in residence " ?

Question XI.—State the laws of reflection and of refraction. Draw the images formed in the following cases, stating their nature : (i) Object at a distance from a concave spherical mirror less than the focal length ; (ii) object at a distance from a convex spherical mirror greater than the focal length : (iii) object at a distance from a double convex lens less than the focal length.

In each case, measure the height of object and image, and verify the relation

$$\frac{\text{Height of object}}{\text{Height of image}}=\frac{u}{v}.$$

The first part was usually well done, the second part badly, there being no attempts made generally to *verify* the relationship as required. Many merely measured u and v and gave a ratio, and then measured the heights of image and object and gave a ratio, without reducing them so that any comparison was obvious ; reduction to decimal fractions would be simplest.

Question XII.—Answer *one* of the following parts: (*a*) Describe, with full experimental and theoretical detail, a quantitative experiment which you have not considered elsewhere in your paper.

Or

(*b*) State what you know of *four* of the following physicists: Archimedes, Boyle, Charles, Galileo, Newton, Aristotle, Alhazen, Heron (Hero).

This was the comic relief for the examiners, part (*b*) being very popular with those who wrote several pages of imaginative history based on their imperfect knowledge of Boyle's law, Charles' law, Archimedes' principle, etc. We met the early gas engine—" Charles worked on gas for the greater part of his life ". Newton was made responsible for work " concerning the ratio of the sign of the angle of insolence ". Archimedes (i) " was an old Roman who once had a bath; this set him thinking, and he discovered his principals "; (ii) " lived a long, long time ago, in the 18th century "; (iii) " lived and worked with Boyle "; (iv) " was, like most other great scientists, a prosecuted Jew ". Whilst, in general, brightening the lives of the examiners, this question secured few marks for the candidates concerned. It is the present intention of the Chief Examiner to include an historical question, as an alternative question, this year; but candidates are warned that it will be quite useless to attempt the question unless they know something of the historical side of the subject. Part (*a*) was poorly attempted, many candidates giving purely qualitative experiments, and many omitting practical detail completely.

INTERMEDIATE CERTIFICATE EXAMINATION. ELEMENTARY SCIENCE (PHYSICS SECTION).

An examination of the results shows that some schools do consistently well, an encouraging percentage of candidates obtaining over 70%; whilst from other schools the marks are generally bad. A comparison of papers from such centres shows that these weaker candidates have evidently a very restricted knowledge of the subject, and are endeavouring merely to pass an examination by giving the limited time available in class to the subject, and reading nothing beyond what the teacher dictates to them. The examiners would urge the necessity for directed reading as an essential part of the course; the results at present, though sufficiently satisfactory as an average, are far from satisfactory when the group distribution of pass and fail is considered; this can only be remedied by compelling students to learn to read and think for themselves.

Question I.—Write a summary of your knowledge of the c.g.s. system of units, stating definitely what are the Standards, and naming and defining the fundamental units.

This question has been set before, and, in view of that fact, the results are surprisingly bad. Many candidates merely produced " tables " of c.g.s. units; a considerable number endeavoured to write a summary of all the units of the c.g.s. system, and to define large numbers of derived units, both of the c.g.s. and British systems. Most completely ignored the Standards and the fundamental units. The question definitely asks for a statement as to what are *the Standards*, for the naming and defining of the *fundamental units*, and for a summary of the candidate's knowledge of the c.g.s. *system* of units. This question can be answered directly from a considered reading of their text books.

Question II.—Describe how you would find the volume of (*a*) a metal cube, edge about 6 inches, (*b*) an apple, (*c*) a piece of " loaf " sugar. How accurate would your result be?

This was not well answered, the simple method of obtaining the volume of the cube by measurement of its sides being missed by many candidates. Many who did it took only one measurement of each side, or in some cases measured one side only. Very many took no measurements, but stated " measure the edge and cube it "—no indication even of apparatus or method being given; the subject is the experimental science Physics, not mensuration or elementary arithmetic. The simplest method of obtaining the volume of the apple was by water displacement (remembering that apples float, and require to be pushed or loaded below the surface). Many candidates used the apple as a sphere, or even a cylinder, and measured its radius. The majority of candidates endeavoured to find the volume of the loaf sugar by water displacement, ignoring or neglecting the breaking up and dissolving of the sugar, or its absorption of water. A simple method is to rub it with butter (or some other fat) and employ water displacement, or to immerse it in " a liquid in which sugar is not soluble and which does not wet it ", which was accepted without the naming of the liquid. In most cases the answers were purely qualitative, very few candidates mentioning the limit of reading of their instruments or methods, or whether they were likely to be correct to within 10% or 100%.

Question III.—What is meant by the weight of a body ?
A glass stopper weighs 200 grms. in air ; when freely suspended in water it appears to weigh 120 grms. ; when freely suspended in another liquid, 110 grms. What is the relative density of the glass, and of the liquid ?

This question was the best answered in the paper ; it was very popular, very many of the candidates from the good centres securing full marks. Although the first part is "repetition work", it was satisfactory to see that candidates were able to reproduce it and show an intelligent appreciation of the principle. In other cases the second part only was done, candidates writing down "formulæ" in which they substituted to obtain a correct answer.

Question IV.—(*a*) Explain why the difference in levels between the mercury surface exposed to the air and that within the closed barometer tube may be taken as a measure of the atmospheric pressure. (*b*) A J-tube is used to verify Boyle's law. The volume of the enclosed air is 25 c.c. when the mercury in the two arms is level, the atmospheric pressure then being 770 mm. What will be the volume of the enclosed air when the difference in mercury levels is (i) 50 mm., (ii) 760 mm. ?

The answers to this were not satisfactory ; many candidates wrote a lot without explaining the effect at all, and the replies were generally bad. The first part is a fundamental question ; there is no reason for a student employing a barometer, or talking in "millimetres of mercury", unless he can answer it. This is book work, and should be familiar to the candidates.

Question V.—(*a*) What is meant by the following : a scale of temperatures ; upper and lower fixed points. (*b*) A copper ball of 4 inches diameter at 20° C. is heated to 200° C. ; its diameter is found to have increased by $\frac{1}{100}$th inch. What is the coefficient of linear expansion of the metal ? (*c*) The volume of a given mass of gas is $1\cdot5$ litres at 0° C. and 765 mm. What is the change in volume when at 91° C. and 750 mm. ?

The majority of candidates replied correctly regarding upper and lower fixed points, except for the omission of reference to pressure ; but few knew what was understood by a scale of temperatures—very necessary knowledge if work on heat is to be understood. Many candidates gave themselves unnecessary work by finding the original volume, then a new volume, of the sphere, and hence the coefficient of cubical and lineal expansion. The idea of *uniform* expansion requires to be impressed on them. The last part of the question was very stereotyped, but even then many candidates made the volume vary directly as the centigrade temperature instead of as the absolute temperature.

Question VI.—(*a*) Why does the temperature of a liquid standing in an open vessel usually fall below that of the air ? (*b*) A copper pot of water equivalent to 90 grms. contains 200 grms. of water and $20\cdot0$ grms. of ice. Into this is placed 700 grms. of lead shot (specific heat $0\cdot030$) at $99°\cdot0$ C. What happens ?

Most candidates who attempted this imagined that the water spontaneously gave up heat to the air, so that the air became heated and the water cooled ; few appreciated that the effect was due to evaporation, and brought in the idea of latent heat (some quoted $L=540$ cals./grm., which of course is only for water, and at 100° C.).

The problem portion was not well attempted, far too many candidates neglecting the heat taken up by the ice in melting ; many even imagined (or said so) that the ice gave out heat in melting.

Question VII.—(*a*) Define the following : velocity, acceleration, force, work, power. (*b*) A force of 400 dynes is applied to a mass of 25 grms. for $\frac{1}{5}$th second. What is its change in velocity, and what average power was required ?

As is general, the definitions were well given by some centres, badly by others. In the second part, some candidates confused "change in velocity" with acceleration ; many confused work and power.

Question VIII.—(*a*) What is meant by the moment of a force about a point ? Explain why the vertical passes through the centre of gravity and the point of attachment of a body freely suspended from a cord. (*b*) A horizontal bar of length 6 feet is supported by two vertical wires attached to either end of it. The bar has a mass of 20 pounds, and one wire can support a load of 25 pounds and the other of 50 pounds without breaking. What is the greatest load that can be hung from the bar, and where must it be attached ?

(*a*) Whilst the definitions were frequently correct, the question was answered intelligently by very few students, those few realising that if the conditions were not satisfied there would be an unbalanced moment (due to the weight) about the point of attachment. (*b*) Many who attempted this obtained the numerical value of the load, but were unable to find its position, not understanding the method of treating these problems by taking moments about a convenient point.

Question IX.—Describe, with full experimental and theoretical detail, any *quantitative* experiment you have performed in connection with a " simple machine ".

This was not a popular question, and was attempted mainly by the weaker candidates. It was not well done, and in many cases the theory of levers or of a system of pulleys was given, without any actual experiment being described. It was taken by some as a request to write of any experiment at all, and replies ranged from Archimedes' principle to the coefficient of linear expansion of a bar.

Question X.—Describe briefly any primary cell which you have used, and state its approximate e.m.f. The difference in potential between the terminals of a cell decreases when a current passes : how do you account for this ?

Question XI.—State Ohm's law. An electric lamp is employed across a 110 volt circuit and takes $0 \cdot 75$ ampere. What is its resistance ? What is meant by the statement that the difference in potential between two points is 100 volts ?

These questions in the electrical section were attempted by very few candidates. The first part of X was generally answered well, the second part badly. In Question XI Ohm's law was generally essentially correct ; the problem was generally correct ; but the last part of the question was answeerd very vaguely, wrongly, or not at all, no one saying that " the potential difference between two points is 100 volts if the work done in transferring 1 coulomb from one point to the other is 100 joules ", or words to the same meaning.

Discussing the paper as a whole : Some candidates wrote far too much, apparently from some centres where they may have been encouraged to " pad ". The best papers generally consisted of only about five pages, whereas very many ran to a dozen or more filled pages ; these latter candidates would be well advised to practise writing brief clear replies, without extraneous matter, and to give the extra time to revision of statements and arithmetic.

When arithmetical calculations are missing (generally obviously removed on waste paper) then it is difficult to check the source of error—it may be a slip in calculation, or may be a fundamental error. Candidates should be instructed not merely to write down an answer, even if they can " do it in their heads ", in case they are wrong, in which case they can get no credit. Too many candidates still attempt five, six or more questions, some of the answers being valueless, and leave them all in the assembled paper ; destruction of all save the four questions they wished examined would, in many cases, have resulted in their passing.

It must finally be emphasised that the Elementary Science papers disclose, far more than do the full Physics papers, the imperative need for the candidate to read for himself under the direction of his teacher ; the standard of the replies, on a general average, is fair ; but from many centres it is going down.