| Candidate Name | Centre Number | Candidate Number |
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**WELSH JOINT EDUCATION COMMITTEE**
**General Certificate of Education**
**Advanced Subsidiary/Advanced**

**CYD-BWYLLGOR ADDYSG CYMRU**
**Tystysgrif Addysg Gyffredinol**
**Uwch Gyfrannol/Uwch**

542/01

# PHYSICS

## ASSESSMENT UNIT PH2: QUANTA AND ELECTRICITY

A.M. FRIDAY, 10 June 2005

(1 hour 30 minutes)

### ADDITIONAL MATERIALS

In addition to this examination paper, you may require a calculator.

### INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

| For Examiner's use only. | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| Total | |

### INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the "Mathematical Data and Relationships" on the back page of this paper.

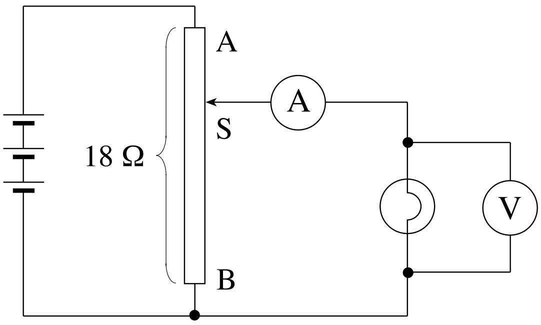
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

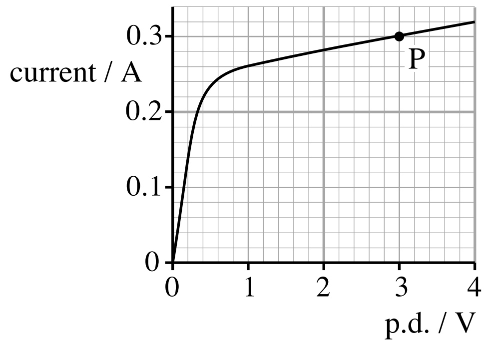
*Fundamental Constants*

| | | | |
|---|---|---|---|
| Avogadro constant | $N_A$ | = | $6{\cdot}0 \times 10^{23}$ $mol^{-1}$ |
| Fundamental electronic charge | $e$ | = | $1{\cdot}6 \times 10^{-19}$ C |
| Mass of an electron | $m_e$ | = | $9{\cdot}1 \times 10^{-31}$ kg |
| Mass of a proton | $m_p$ | = | $1{\cdot}67 \times 10^{-27}$ kg |
| Molar gas constant | $R$ | = | $8{\cdot}3$ J $mol^{-1}$ $K^{-1}$ |
| Acceleration due to gravity at sea level | $g$ | = | $9{\cdot}8$ m $s^{-2}$ |
| [Gravitational field strength at sea level | $g$ | = | $9{\cdot}8$ N $kg^{-1}$] |
| Universal constant of gravitation | $G$ | = | $6{\cdot}7 \times 10^{-11}$ N $m^2$ $kg^{-2}$ |
| Planck constant | $h$ | = | $6{\cdot}6 \times 10^{-34}$ J s |
| Unified mass unit | 1 u | = | $1{\cdot}66 \times 10^{-27}$ kg |
| Boltzmann constant | $k$ | = | $1{\cdot}38 \times 10^{-23}$ $JK^{-1}$ |
| Speed of light *in vacuo* | $c$ | = | $3{\cdot}0 \times 10^{8}$ m $s^{-1}$ |
| Permittivity of free space | $\varepsilon_o$ | = | $8{\cdot}9 \times 10^{-12}$ F $m^{-1}$ |
| Permeability of free space | $\mu_o$ | = | $4\pi \times 10^{-7}$ H $m^{-1}$ |

Examiner only
*Arholwr yn unig*

**1.** Using the circuit shown, the current through a filament lamp is found for various p.d.s placed across it.




*(a)* For point **P** on the graph calculate

(i) the *power* supplied to the lamp, [2]

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(ii) the *resistance* of the lamp. [2]

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*(b)* In the circuit diagram above, AB is a uniform carbon track of resistance 18 Ω. To obtain point **P** on the graph, the sliding contact, S, is $\frac{1}{6}$ of the way down the track from A.

(i) Show that, when obtaining point **P**, the resistance of the parallel combination of the bulb and the section SB of track is 6.0 Ω. [3]

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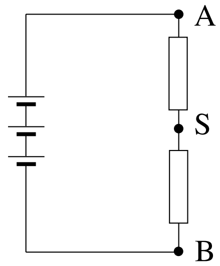
(ii) The circuit above can be represented by the potential divider shown alongside. Mark in the values of the two resistances on this circuit diagram and hence calculate the p.d. across the battery terminals. [3]

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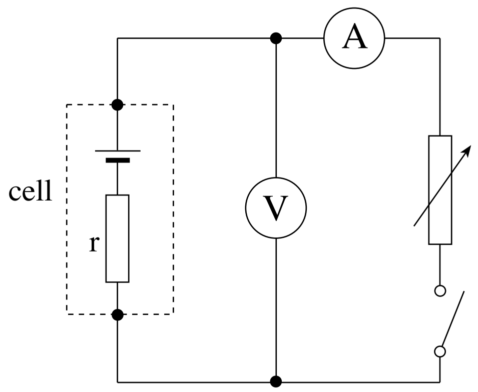
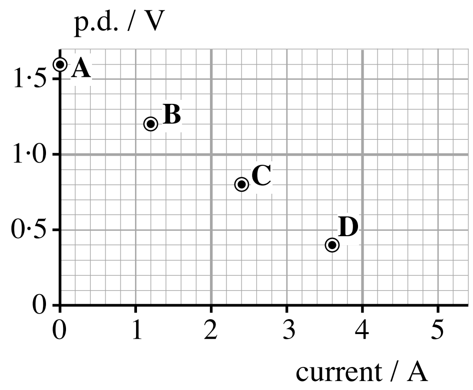
**2.** The diagram shows a circuit used to investigate how the p.d. across the terminals of a cell depends on the current. Four pairs of readings were taken. They are plotted on the grid as **A**, **B**, **C** and **D**.




*(a)* For which one of the points was the switch **open**? ...................... [1]

*(b)* (i) Define the e.m.f. of a cell. [2]

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(ii) Write down the e.m.f. of the cell above. ...................... [1]

*(c)* (i) For point **D**, calculate the p.d. across the internal resistance. [1]

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(ii) **Hence** calculate the *internal resistance* of the cell. [2]

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*(d)* (i) Make use of the graph to determine the maximum current the cell could supply. [1]

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(ii) Calculate the quantity $\dfrac{\text{e.m.f. of cell}}{\text{maximum current cell can supply}}$ . [1]

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(iii) What is the physical significance of this quantity? [1]

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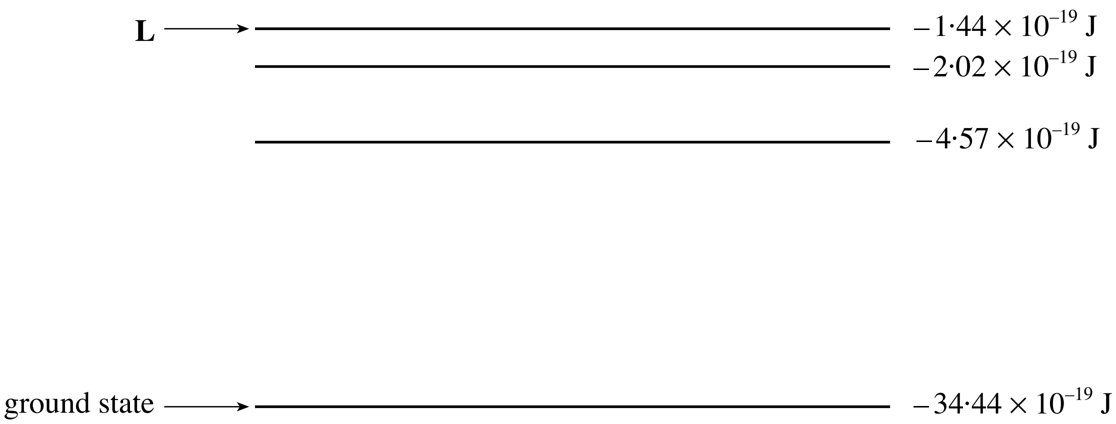
**3.** *(a)* Neon has two commonly-occurring *isotopes*, $^{20}_{10}Ne$ and $^{22}_{10}Ne$.

(i) Define the term *isotopes*. [2]

(ii) Explain quantitatively how your definition applies to these isotopes of neon. [2]

*(b)* A simplified energy level diagram for a neon atom is given below.




In one kind of laser, neon atoms are raised from the *ground state* to the energy level marked **'L'**. When 'stimulated' to do so, the atoms then emit radiation of wavelength 633 nm.

(i) Calculate the energy needed to raise a neon atom from the ground state to **L**. [1]

(ii) Name the region of the electromagnetic spectrum in which the 633 nm wavelength lies. [1]

(iii) Show the photon energy for this wavelength of light is $3{\cdot}13 \times 10^{-19}$ J. [Refer to the data on page 2.] [2]

(iv) Draw an arrow on the diagram to show the transition between energy levels which occurs when a photon of this energy is **emitted**. [2]

**4.** *(a)* The current through a wire is related to the drift velocity of its free electrons by the formula

$$I = nAve.$$

State the meaning of $n$. [1]

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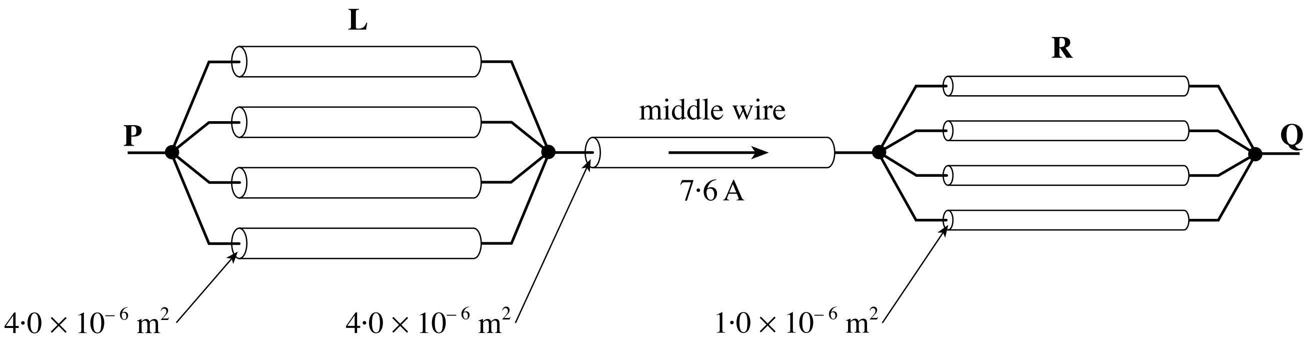
*(b)* In the diagram the four left hand wires **L** are identical to each other and to the middle wire. The four right hand wires **R** are identical to each other. The cross-sectional areas of the wires are shown in the diagram. **All** of the wires are made of copper.

**P** and **Q** are connected to a battery, and there is a current of 7·6 A through the middle wire. The drift velocity of free electrons in the middle wire is $1{\cdot}4 \times 10^{-4}$ ms$^{-1}$.




(i) Calculate

(I) the value of $n$ for copper, [Refer to the data on page 2.] [3]

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(II) the number of free electrons which pass through any cross-section of the middle wire per second. [2]

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(ii) Calculate the drift velocity of free electrons in the left hand wires **L**. [2]

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(iii) Explain why the drift velocity is the same in the right hand wires **R** as in the middle wire. [2]

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**5.** *(a)* (i) State briefly how fast-moving electrons can be made to produce X-rays. [1]

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(ii) Give **two** properties which X-rays and fast-moving electrons both possess. [2]

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(iii) Give **one** way in which X-rays and fast-moving electrons differ in their properties. [1]

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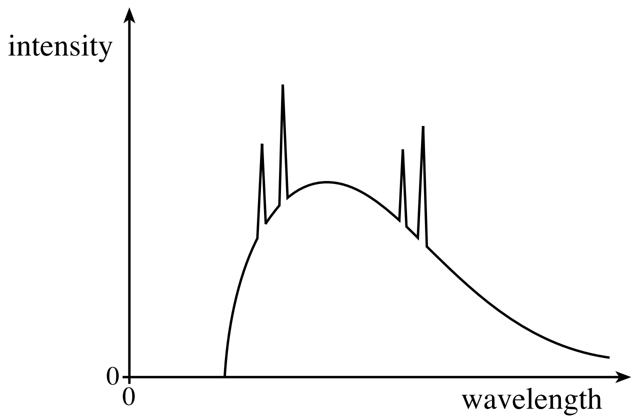
*(b)* A graph of intensity against wavelength is sketched for the X-rays from an X-ray tube.




(i) Label the *cut-off wavelength*, $\lambda_{min}$. [1]

(ii) The accelerating voltage applied to the X-ray tube is now changed so that $\lambda_{min}$ is doubled.

(I) Sketch, on the same grid, a graph of intensity against wavelength for the same X-ray tube with the new accelerating voltage. [3]

(II) $\lambda_{min}$ is related to the accelerating voltage, $V$, by the equation $eV = \frac{hc}{\lambda_{min}}$.

State how the accelerating voltage must be changed in order for the cut-off wavelength to be doubled. [2]

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**6.** *(a)* (i) Complete the following version, **in words**, of Einstein's photoelectric equation. [2]

{Maximum K.E. of emitted electron} = {.................................. ..................................} − {Work function of surface}

(ii) Define *work function*. [1]

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*(b)* When violet light falls on a sheet of barium metal held in an insulating stand, the barium acquires a charge.

(i) Explain why this would be expected to happen, stating the sign of the charge acquired. [3]

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(ii) The effect does not occur if red light is shone on to the same surface. Explain why not. [2]

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*(c)* (i) The work function of barium is $4{\cdot}0 \times 10^{-19}$ J. Violet light of **frequency** $7{\cdot}0 \times 10^{14}$ Hz is shone on to a barium surface. Use Einstein's photoelectric equation to calculate the maximum kinetic energy of emitted electrons

(I) in joules, [Refer to the data on page 2.] [2]

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(II) in eV. [Refer to the data on page 2.] [2]

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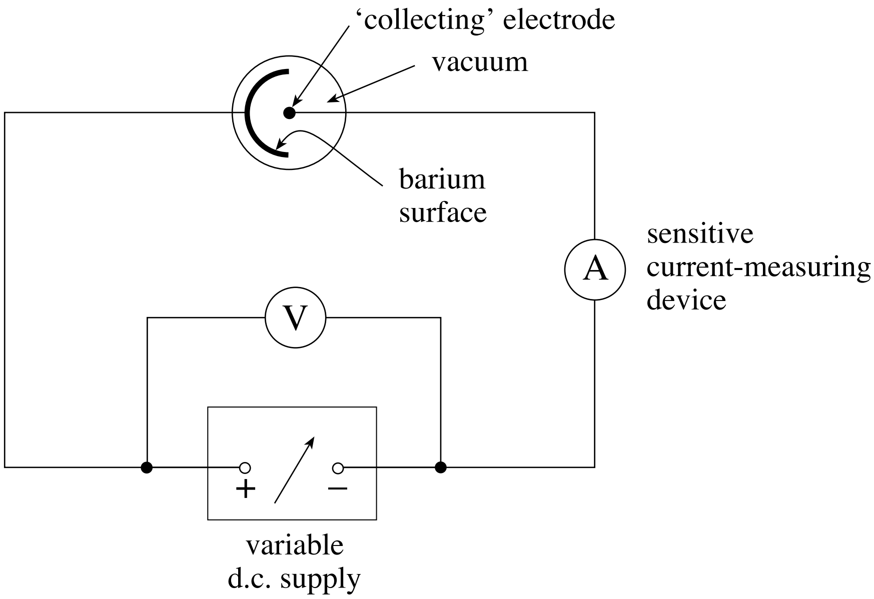
(ii) Describe carefully how you would make an experimental check of your answer to *(c)* (i) (II). A suitable violet light source is available, as well as the apparatus shown in the diagram. [5]

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(iii) The intensity of the violet light is now increased.

(I) What effect, if any, would this have on the maximum kinetic energy of the emitted electrons? [1]

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(II) Justify your answer to (I) in terms of photons. [2]

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**Turn over.**

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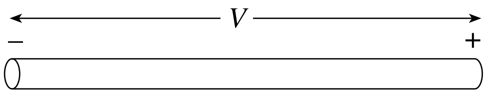
**7.** *(a)* A p.d. is applied between the ends of a copper wire, as shown.




(i) Describe the motion of free electrons in the wire, according to a simple model of a metal. [2]

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(ii) Explain how the motion of the free electrons is affected if the wire's temperature is raised. [Assume that the p.d. remains the same.] [2]

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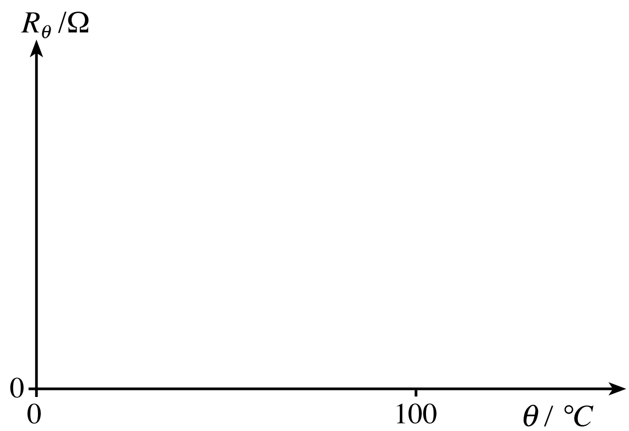
*(b)* (i) Using the axes provided, sketch a graph of the resistance, $R_\theta$, of a metal wire against the **celsius** temperature, $\theta$. [2]




(ii) $R_\theta$ is related to $\theta$ by the equation

$$R_\theta = R_o\ (1 + \alpha\,\theta)$$

in which $\alpha$ is the *temperature coefficient of resistance* of the metal.

(I) Label $R_o$ clearly on your graph. [1]

(II) What property of the graph does $R_o\,\alpha$ represent? [1]

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*(c)* A student performs various experiments on a piece of copper wire.

(i) He measures the resistance of the wire to be 1·08 Ω at 18·0°C (room temperature).

(I) Calculate $R_o$ [See part *(b)* (ii)]. The temperature coefficient of resistance of copper is $4{\cdot}4 \times 10^{-3}\ °C^{-1}$. [2]

...

(II) Calculate the change in resistance of the wire which would have occurred as a result of a **rise** in room temperature of 7·0°C. [3]

...

(ii) The student measures the length and **diameter** of the wire, finding these to be 4·50 m and $3{\cdot}00 \times 10^{-4}$ m when the resistance is 1·08 Ω (that is at 18·0°C). Use these values to calculate the resistivity of copper at 18·0°C. [4]

...

(iii) He then puts the wire under tension, making it permanently longer. Its new length is measured to be 6·00 m, and its new resistance to be 1·92 Ω. Calculate the expected value for the wire's new diameter, stating your assumptions. [3]

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**Turn over.**

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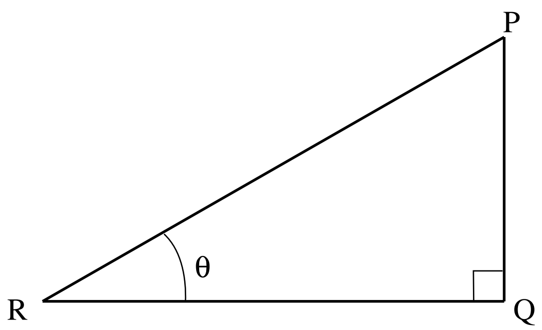
## Mathematical Data and Relationships

### SI multipliers

| Multiple | Prefix | Symbol |
|---|---|---|
| $10^{-18}$ | atto | a |
| $10^{-15}$ | femto | f |
| $10^{-12}$ | pico | p |
| $10^{-9}$ | nano | n |
| $10^{-6}$ | micro | μ |
| $10^{-3}$ | milli | m |

| Multiple | Prefix | Symbol |
|---|---|---|
| $10^{-2}$ | centi | c |
| $10^{3}$ | kilo | k |
| $10^{6}$ | mega | M |
| $10^{9}$ | giga | G |
| $10^{12}$ | tera | T |
| $10^{15}$ | peta | P |

### Geometry and trigonometry




$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

### Areas and Volumes

Area of a circle $= \pi r^2 = \dfrac{\pi d^2}{4}$

Area of a triangle = ½ base × height

| Solid | Surface area | Volume |
|---|---|---|
| rectangular block | $2(lh + hb + lb)$ | $lbh$ |
| cylinder | $2\pi r(r + h)$ | $\pi r^2 h$ |
| sphere | $4\pi r^2$ | $\frac{4}{3}\pi r^3$ |