Pharmacopoeias. In *Eur.* (see p.vii).
Ph. Eur. 6.2 (Magnesium Acetate Tetrahydrate). Colourless crystals or a white or almost white, crystalline powder. Freely soluble in water and in alcohol. A 5% solution in water has a pH of 7.5 to 8.5.

Equivalence. Each g of magnesium acetate (tetrahydrate) represents about 4.7 mmol of magnesium and the equivalent of bicarbonate. Magnesium acetate (tetrahydrate) 8.83 g is equivalent to about 1 g of magnesium.

Magnesium Ascorbate

Magnesio, ascorbato de.

$(C_6H_7O_6)_2Mg$ = 374.5.
CAS — 15431-40-0.

Equivalence. Each g of magnesium ascorbate (anhydrous) represents about 2.7 mmol of magnesium. Magnesium ascorbate (anhydrous) 15.4 g is equivalent to about 1 g of magnesium.

Magnesium Aspartate

Bázisos magnézium-aszpartát-dihidrát; Magnesii aspartas dihydricus; Magnesii Hydrogenoaspartas Dihydricus; Magnesio, aspartato de; Magnésium (aspartate de) dihydraté; Magnesium Aspartate Dihydrate; Magnesiumaspartaattidihydraatti; Magnesiumaspartatdihydrat; Magnesium-hydrogen-aspartát dihydrát; Magnio aspartatas dihidratas. Magnesium aminosuccinate dihydrate; Magnesium di[(*S*)-2-aminohydrogenobutane-1,4-dioate].

$C_8H_{12}MgN_2O_8,2H_2O$ = 324.5.
CAS — 18962-61-3 (anhydrous magnesium aspartate); 2068-80-6 (anhydrous magnesium aspartate or magnesium aspartate dihydrate); 7018-07-7 (magnesium aspartate tetrahydrate);.
ATC — A12CC05.
ATC Vet — QA12CC05.

Pharmacopoeias. *Eur.* (see p.vii) includes the dihydrate form of the (*S*)-aspartate. *Ger.* includes the tetrahydrate form of the racemic aspartate.
Ph. Eur. 6.2 (Magnesium Aspartate Dihydrate; Magnesium Aspartate BP 2008). A white or almost white, crystalline powder or colourless crystals. Freely soluble in water. A 2.5% solution in water has a pH of 6.0 to 8.0.

Equivalence. Each g of magnesium aspartate (dihydrate) represents about 3.1 mmol of magnesium. Magnesium aspartate (dihydrate) 13.4 g is equivalent to about 1 g of magnesium.

Each g of magnesium aspartate (tetrahydrate) represents about 2.8 mmol of magnesium. Magnesium aspartate (tetrahydrate) 14.8 g is equivalent to about 1 g of magnesium.

Magnesium Chloride

Chlorid hořečnatý; Chlorure de Magnésium Cristallisé; Cloreto de Magnésio; E511; Magnesii chloridum; Magnesio, cloruro de; Magnesium Chloratum; Magnésium, chlorure de; Magnesiumklorid; Magnesiumkloridi; Magnézium-klorid; Magnezu chlorek; Magnio chloridas.

$MgCl_2,xH_2O$ = 95.21 (anhydrous); 203.3 (hexahydrate).
CAS — 7786-30-3 (anhydrous magnesium chloride); 7791-18-6 (magnesium chloride hexahydrate).
ATC — A12CC01; B05XA11.
ATC Vet — QA12CC01; QB05XA11.

Pharmacopoeias. *Eur.* (see p.vii), *US*, and *Viet*. include the hexahydrate.
Eur. also includes magnesium chloride 4.5-hydrate.
Ph. Eur. 6.2 (Magnesium Chloride Hexahydrate; Magnesii Chloridum Hexahydricum). Colourless, hygroscopic crystals. Very soluble in water; freely soluble in alcohol. Store in airtight containers.
Ph. Eur. 6.2 (Magnesium Chloride 4.5-Hydrate; Magnesii Chloridum 4.5-Hydricum; Partially Hydrated Magnesium Chloride BP 2008). A white or almost white, hygroscopic, granular powder. Very soluble in water; freely soluble in alcohol. Store in airtight containers.
USP 31 (Magnesium Chloride). Colourless, odourless, deliquescent flakes or crystals, which lose water when heated to 100° and lose hydrochloric acid when heated to 110°. Very soluble in water; freely soluble in alcohol. pH of a 5% solution in water is between 4.5 and 7.0. Store in airtight containers.

Equivalence. Each g of magnesium chloride (hexahydrate) represents about 4.9 mmol of magnesium and 9.8 mmol of chloride. Magnesium chloride (hexahydrate) 8.36 g is equivalent to about 1 g of magnesium.

Magnesium Gluceptate

Magnesio, glucoheptonato de; Magnesium Glucoheptonate.

$C_{14}H_{26}MgO_{16}$ = 474.7.

Equivalence. Each g of magnesium gluceptate (anhydrous) represents about 2.1 mmol of magnesium. Magnesium gluceptate (anhydrous) 19.5 g is equivalent to about 1 g of magnesium.

Magnesium Gluconate

Magnesii gluconas; Magnesio, gluconato de; Magnésium, gluconate de. Magnesium D-gluconate hydrate.

$C_{12}H_{22}MgO_{14}(+xH_2O)$ = 414.6 (anhydrous).
CAS — 3632-91-5 (anhydrous magnesium gluconate); 59625-89-7 (magnesium gluconate dihydrate).
ATC — A12CC03.
ATC Vet — QA12CC03.

Pharmacopoeias. In *Eur.* (see p.vii), which allows either anhydrous or hydrated forms, and in *US*, which allows either anhydrous or the dihydrate.
Ph. Eur. 6.2 (Magnesium Gluconate). A white or almost white, amorphous, hygroscopic, crystalline or granular powder. Freely soluble in water; slightly soluble in alcohol; very slightly soluble in dichloromethane. Store in airtight containers.
USP 31 (Magnesium Gluconate). Colourless crystals or a white powder or granules. Is odourless. Freely soluble in water; very slightly soluble in alcohol; insoluble in ether. pH of a 5% solution in water is between 6.0 and 7.8.

Equivalence. Each g of magnesium gluconate (anhydrous) represents about 2.4 mmol of magnesium. Magnesium gluconate (anhydrous) 17.1 g is equivalent to about 1 g of magnesium.

Magnesium Glycerophosphate

Glycerofosforečnan hořečnatý; Magnesii glycerophosphas; Magnesio, glicerofosfato de; Magnesium Glycerinophosphate; Magnésium, glycérophosphate de; Magnesiumglycerofosfat; Magnesiumglyserofosfaatti; Magnézium-glicerofoszfát; Magnio glicerofosfatas.

$C_3H_7MgO_6P(+xH_2O)$ = 194.4 (anhydrous).
CAS — 927-20-8 (anhydrous magnesium glycerophosphate).

Pharmacopoeias. In *Eur.* (see p.vii).
Ph. Eur. 6.2 (Magnesium Glycerophosphate). A mixture, in variable proportions, of magnesium (*R,S*)-2,3-dihydroxypropyl phosphate and magnesium 2-hydroxy-1-(hydroxymethyl)ethyl phosphate. It may be hydrated. A white or almost white, hygroscopic powder. Practically insoluble in alcohol; dissolves in dilute solutions of acids. Store in airtight containers.

Equivalence. Each g of magnesium glycerophosphate (anhydrous) represents about 5.1 mmol of magnesium. Magnesium glycerophosphate (anhydrous) 8 g is equivalent to about 1 g of magnesium.

Magnesium Lactate

Magnesii lactas; Magnesio, lactato de; Magnésium, lactate de; Magnesiumlaktaatti; Magnesiumlaktat; Magnesium-laktát; Magnezu mleczan. Magnesium 2-hydroxypropionate.

$C_6H_{10}MgO_6$ = 202.4.
CAS — 18917-93-6.
ATC — A12CC06.
ATC Vet — QA12CC06.

Pharmacopoeias. *Eur.* (see p.vii) includes the dihydrate.
Ph. Eur. 6.2 (Magnesium Lactate Dihydrate; Magnesii Lactas Dihydricus). A white or almost white, crystalline or granular powder. Slightly soluble in water; soluble in boiling water; practically insoluble in alcohol. A 5% solution in water has a pH of 6.5 to 8.5.

Equivalence. Each g of magnesium lactate (anhydrous) represents about 4.9 mmol of magnesium. Magnesium lactate (anhydrous) 8.33 g is equivalent to about 1 g of magnesium.

Magnesium Phosphate

Magnesio, fosfato de; Tribasic Magnesium Phosphate; Trimagnesium Phosphate.

$Mg_3(PO_4)_2,5H_2O$ = 352.9.
CAS — 7757-87-1 (anhydrous magnesium phosphate); 10233-87-1 (magnesium phosphate pentahydrate).
ATC — B05XA10.
ATC Vet — QB05XA10.

Pharmacopoeias. In *US*.
Ger. includes Magnesium Hydrogen Phosphate Trihydrate ($MgHPO_4,3H_2O$ = 174.3).
USP 31 (Magnesium Phosphate). A white, odourless, powder. Almost insoluble in water; readily soluble in dilute mineral acids.

Equivalence. Each g of magnesium phosphate (pentahydrate) represents about 8.5 mmol of magnesium and 5.7 mmol of phosphate. Magnesium phosphate (pentahydrate) 4.84 g is equivalent to about 1 g of magnesium.

Magnesium Pidolate *(pINNM)*

Magnesii pidolas; Magnésium, pidolate de; Magnesium Pyroglutamate; Magnesiumpidolaatti; Magnesiumpidolat; Magnesium-pidolát; Magnézium-pidolát; Magnio pidolatas; Pidolate de Magnesium; Pidolato de magnesio. Magnesium 5-oxopyrrolidine-2-carboxylate.

Магния Пидолат

$(C_5H_6NO_3)_2Mg$ = 280.5.
CAS — 62003-27-4.
ATC — A12CC08.
ATC Vet — QA12CC08.

Pharmacopoeias. In *Eur.* (see p.vii).
Ph. Eur. 6.2 (Magnesium Pidolate). An amorphous, white or almost white, hygroscopic powder. Very soluble in water; practically insoluble in dichloromethane; soluble in methyl alcohol. A 10% solution in water has a pH of 5.5 to 7.0. Store in airtight containers.

Equivalence. Each g of magnesium pidolate (anhydrous) represents about 3.6 mmol of magnesium. Magnesium pidolate (anhydrous) 11.5 g is equivalent to about 1 g of magnesium.

Magnesium Sulfate

518; Epsom Salts; Magnesii sulfas; Magnesio, sulfato de; Magnésium, sulfate de; Magnesium Sulphate; Magnesiumsulfaatti; Magnesiumsulfat; Magnézium-szulfát; Magnezu siarczan; Magnio sulfatas; Sal Amarum; Sel Anglais; Sel de Sedlitz; Síran hořečnatý.

$MgSO_4,xH_2O$ = 120.4 (anhydrous); 246.5 (heptahydrate).
CAS — 7487-88-9 (anhydrous magnesium sulfate); 10034-99-8 (magnesium sulfate heptahydrate).
ATC — A06AD04; A12CC02; B05XA05; D11AX05; V04CC02.
ATC Vet — QA06AD04; QA12CC02; QB05XA05; QD11AX05; QV04CC02.

Pharmacopoeias. *Chin.*, *Eur.* (see p.vii), *Int.*, *Jpn*, and *Viet.* include the heptahydrate.
US allows the dried form, the monohydrate, or the heptahydrate form.
The dried form is included in *Br.*
Ph. Eur. 6.2 (Magnesium Sulphate Heptahydrate; Magnesii Sulfas Heptahydricus). A white or almost white, crystalline powder or brilliant, colourless crystals. Freely soluble in water; very soluble in boiling water; practically insoluble in alcohol.
The BP 2008 gives Epsom Salts as an approved synonym.
BP 2008 (Dried Magnesium Sulphate). A white odourless or almost odourless powder, prepared by drying magnesium sulfate (heptahydrate) at 100° until it has lost about 25% of its weight; it contains 62 to 70% of $MgSO_4$. Freely soluble in water; more rapidly soluble in hot water.
The BP gives Dried Epsom Salts as an approved synonym.
USP 31 (Magnesium Sulfate). It is the dried form, monohydrate, or the heptahydrate. Small, colourless crystals, usually needle-like. It effloresces in warm dry air. Soluble 1 in 0.8 of water and 1 in 0.5 of boiling water; freely but slowly soluble 1 in 1 of glycerol; sparingly soluble in alcohol. pH of a 5% solution in water is between 5.0 and 9.2.

Equivalence. Each g of magnesium sulfate (heptahydrate) represents about 4.1 mmol of magnesium. Magnesium sulfate (heptahydrate) 10.1 g is equivalent to about 1 g of magnesium.

Adverse Effects

Excessive parenteral doses of magnesium salts lead to the development of hypermagnesaemia, important signs of which are respiratory depression and loss of deep tendon reflexes, both due to neuromuscular blockade. Other symptoms of hypermagnesaemia may include nausea, vomiting, flushing of the skin, thirst, hypotension due to peripheral vasodilatation, drowsiness, confusion, slurred speech, double vision, muscle weakness, bradycardia, coma, and cardiac arrest.

Hypermagnesaemia is uncommon after oral magnesium salts except in the presence of renal impairment. Ingestion of magnesium salts may cause gastrointestinal irritation and watery diarrhoea.

Effects on the gastrointestinal tract. There are isolated reports of paralytic ileus in patients receiving magnesium salts.[1,2] Delayed intestinal transit has also been reported in a neonate who received an intramuscular overdose of magnesium.[3] See also Pregnancy, under Precautions, below.

1. Hill WC, *et al*. Maternal paralytic ileus as a complication of magnesium sulfate tocolysis. *Am J Perinatol* 1985; **2:** 47–8.
2. Golzarian J, *et al*. Hypermagnesemia-induced paralytic ileus. *Dig Dis Sci* 1994; **39:** 1138–42.
3. Narchi H. Neonatal hypermagnesemia: more causes and more symptoms. *Arch Pediatr Adolesc Med* 2001; **155:** 1074.

Hypersensitivity. Hypersensitivity reactions characterised by urticaria were described in 2 women after receiving magnesium sulfate intravenously.[1]

1. Thorp JM, *et al.* Hypersensitivity to magnesium sulfate. *Am J Obstet Gynecol* 1989; **161:** 889–90.

Treatment of Adverse Effects

The management of hypermagnesaemia is reviewed on p.1668.

Hypermagnesaemia. A patient with hypermagnesaemia of a degree that is normally fatal was successfully treated using assisted ventilation, calcium chloride administered intravenously, and forced diuresis with mannitol infusions.[1] In another report, a 7-year-old boy given an Epsom salt (magnesium sulfate) enema for abdominal cramping, developed asystole and died, despite aggressive attempts at resuscitation. Such enemas should be avoided because of the risk of significant, unpredictable rectal absorption, leading to toxic hypermagnesaemia.[2]

1. Bohman VR, Cotton DB. Supralethal magnesemia with patient survival. *Obstet Gynecol* 1990; **76:** 984–6.
2. Tofil NM, *et al.* Fatal hypermagnesaemia caused by an Epsom salt enema: a case illustration. *South Med J* 2005; **98:** 253–6.

Precautions

Parenteral magnesium salts should generally be avoided in patients with heart block or severe renal impairment. They should be used with caution in less severe degrees of renal impairment and in patients with myasthenia gravis. Patients should be monitored for clinical signs of excess magnesium (see Adverse Effects, above), particularly when being treated for conditions not associated with hypomagnesaemia such as eclampsia. An intravenous preparation of a calcium salt should be available in case of toxicity. When used for hypomagnesaemia, serum-magnesium concentrations should be monitored.

Magnesium crosses the placenta. When used in pregnant women, fetal heart rate should be monitored and use within 2 hours of delivery should be avoided (see also Pregnancy, below).

Oral magnesium salts should be used cautiously in patients with renal impairment. Taking with food may decrease the incidence of diarrhoea. Chronic diarrhoea from long-term use may result in electrolyte imbalance.

Breast feeding. In breast milk samples from 10 pre-eclamptic women given magnesium sulfate, mean magnesium concentrations 24 hours after delivery were about 6.4 mg per 100 mL, and significantly higher than those in control subjects. However, by 48 and 72 hours after delivery, values were not significantly different. In both treated and control subjects, milk-magnesium concentrations were about twice those of maternal plasma concentrations. Although total doses of magnesium given to mothers may differ, the authors considered any increased magnesium load to a breast-fed infant to be quite small, about 1.5 mg of additional magnesium daily, and unlikely to significantly alter magnesium clearance from the neonate.[1] Based on this, the American Academy of Pediatrics considers that use of magnesium sulfate is therefore usually compatible with breast feeding.[2]

1. Cruikshank DP, *et al.* Breast milk magnesium and calcium concentrations following magnesium sulfate treatment. *Am J Obstet Gynecol* 1982; **143:** 685–8.
2. American Academy of Pediatrics. The transfer of drugs and other chemicals into human milk. *Pediatrics* 2001; **108:** 776–89. Correction. *ibid.*; 1029. Also available at: http://aappolicy.aappublications.org/cgi/content/full/pediatrics%3b108/3/776 (accessed 18/05/04)

Hepatic disorders. Severe hypermagnesaemia and hypercalcaemia developed in 2 patients with hepatic encephalopathy given magnesium sulfate enemas; both patients died, one during and one after asystole. It was recommended that patients with liver disease who might develop renal impairment, or in whom renal failure is established, should not be prescribed enemas containing magnesium for treatment of hepatic encephalopathy as serious magnesium toxicity can occur, which may contribute to death.[1]

1. Collinson PO, Burroughs AK. Severe hypermagnesaemia due to magnesium sulphate enemas in patients with hepatic coma. *BMJ* 1986; **293:** 1013–14. Correction. *ibid.*; 1222.

Pregnancy. The meconium-plug syndrome (abdominal distention and failure to pass meconium) has been described in 2 neonates who were hypermagnesaemic after their mothers had received magnesium sulfate for eclampsia.[1] It was believed that the hypermagnesaemia may have depressed the function of intestinal smooth muscle. See also Effects on the Gastrointestinal Tract, above. In 36 hypermagnesaemic infants born to pre-eclamptic mothers treated with magnesium sulfate, significant neurobehavioural impairment persisted for over 24 hours after birth. Impairment was manifest by prolonged weakness in activities such as head lag, ventral suspension, suck reflex, and cry response; improvement corresponded to the decrease in plasma-magnesium concentrations.[2]

In studies in women with[3] and without[4] pre-eclampsia there were decreases in short-term fetal heart rate variability when women were given intravenous magnesium sulfate; however, although variability is considered a sign of fetal well-being the decrease was considered clinically insignificant.

1. Sokal MM, *et al.* Neonatal hypermagnesemia and the meconium-plug syndrome. *N Engl J Med* 1972; **286:** 823–5.
2. Rasch DK, *et al.* Neurobehavioral effects of neonatal hypermagnesemia. *J Pediatr* 1982; **100:** 272–6.
3. Atkinson MW, *et al.* The relation between magnesium sulfate therapy and fetal heart rate variability. *Obstet Gynecol* 1994; **83:** 967–70.
4. Hallak M, *et al.* The effect of magnesium sulfate on fetal heart rate parameters: a randomized, placebo-controlled trial. *Am J Obstet Gynecol* 1999; **181:** 1122–7.

Interactions

Parenteral magnesium sulfate potentiates the effects of competitive and depolarising neuromuscular blockers (p.1904). The neuromuscular blocking effects of parenteral magnesium and aminoglycoside antibacterials may be additive. Similarly, parenteral magnesium sulfate and nifedipine have been reported to have additive effects (p.1353).

Oral magnesium salts decrease the absorption of tetracyclines and bisphosphonates, and doses should be separated by a number of hours.

Pharmacokinetics

About one-third of magnesium is absorbed from the small intestine after oral doses and even soluble magnesium salts are generally very slowly absorbed. The fraction of magnesium absorbed increases if magnesium intake decreases. In plasma, about 25 to 30% of magnesium is protein bound. Parenteral magnesium salts are excreted mainly in the urine, and oral doses are eliminated in the urine (absorbed fraction) and the faeces (unabsorbed fraction). Small amounts are distributed into breast milk. Magnesium crosses the placenta.

Human Requirements

Magnesium is the second most abundant cation in intracellular fluid and is an essential body electrolyte which is a cofactor in numerous enzyme systems.

The body is very efficient at maintaining magnesium concentrations by regulating absorption and renal excretion, and symptoms of deficiency are rare. It is therefore difficult to establish a daily requirement.

Foods rich in magnesium include nuts, unmilled grains, and green vegetables.

UK and US recommended dietary intake. In the United Kingdom dietary reference values (DRV—see Human Requirements, p.1925)[1] and in the United States recommended daily allowances (RDA)[2] have been published for magnesium. In the UK the estimated average requirement (EAR) is 200 mg (or 8.2 mmol) daily for adult females and 250 mg (or 10.3 mmol) daily for adult males; the reference nutrient intake (RNI) is 270 mg (or 10.9 mmol) daily for adult females and 300 mg (or 12.3 mmol) daily for adult males; no increment is recommended during pregnancy but an increment of 50 mg (or 2.1 mmol) daily in the RNI is advised during lactation. In the USA under the new dietary reference intakes an EAR of 330 to 350 mg daily has been set in adult males and 255 to 265 mg daily in adult females; the corresponding RDAs are 400 to 420 mg and 310 to 320 mg daily.[2] An increase in RDA to 350 to 360 mg is recommended during pregnancy but the standard RDA is considered adequate during lactation. A tolerable upper intake level of 350 mg daily has been set for adults.[2]

1. DoH. Dietary reference values for food energy and nutrients for the United Kingdom: report of the panel on dietary reference values of the committee on medical aspects of food policy. *Report on health and social subjects 41*. London: HMSO, 1991.
2. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes of the Food and Nutrition Board. *Dietary Reference Intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride*. Washington, DC: National Academy Press, 1999. Also available at: http://www.nap.edu/openbook.php?isbn=0309063507 (accessed 21/07/08)

Uses and Administration

Some magnesium salts are given as a source of magnesium ions in the treatment of **magnesium deficiency and hypomagnesaemia** (p.1668). Doses may be expressed in terms of mmol or mEq of magnesium, mass (mg) of magnesium, or mass of magnesium salt (for comparative purposes, see Table 2, above). In acute or severe hypomagnesaemia, magnesium may be given parenterally, usually as the chloride or sulfate. One suggested regimen is 20 mmol of magnesium in 1 litre of infusion solution (glucose 5% or sodium chloride 0.9%) given *intravenously* over 3 hours. Alternatively, 35 to 50 mmol of magnesium in 1 litre of infusion solution may be given over a period of 12 to 24 hours. Up to a total of 160 mmol may be required over 5 days. In those receiving parenteral nutrition, doses of about 12 mmol magnesium daily may be given to prevent recurrence of the deficit. Magnesium sulfate can also be given *intramuscularly* for severe magnesium deficiency. A recommended dose is 1 mmol/kg of magnesium, given over a period of 4 hours; this route is stated to be painful. Careful monitoring of plasma-magnesium and other electrolyte concentrations is essential. Doses should be reduced in renal impairment. Other salts which are, or have been, used parenterally include magnesium ascorbate, magnesium aspartate hydrochloride, and magnesium pidolate.

Table 2. Some magnesium salts and their magnesium content.

Magnesium salt	Magnesium content per g		
	mg	mmol	mEq
Magnesium acetate (tetrahydrate)	113	4.7	9.3
Magnesium ascorbate (anhydrous)	65	2.7	5.3
Magnesium aspartate (dihydrate)	75	3.1	6.2
Magnesium aspartate (tetrahydrate)	67	2.8	5.5
Magnesium chloride (hexahydrate)	120	4.9	9.8
Magnesium gluceptate (anhydrous)	51	2.1	4.2
Magnesium gluconate (anhydrous)	59	2.4	4.8
Magnesium glycerophosphate (anhydrous)	125	5.1	10.3
Magnesium lactate (anhydrous)	120	4.9	9.9
Magnesium phosphate (pentahydrate)	207	8.5	17.0
Magnesium pidolate (anhydrous)	87	3.6	7.1
Magnesium sulfate (heptahydrate)	99	4.1	8.1

In simple deficiency states magnesium salts may be given *orally* in doses adjusted according to individual requirements. For preventing recurrence of hypomagnesaemia, doses of 24 mmol daily in divided doses have been recommended. Salts that are, or have been, used orally include magnesium aspartate, magnesium chloride, magnesium citrate, magnesium fluoride, magnesium gluceptate, magnesium gluconate, magnesium glycerophosphate, magnesium lactate, magnesium levulinate, magnesium orotate, and magnesium pidolate.

Magnesium salts such as the carbonate, hydroxide, oxide, and trisilicate are widely used for their **antacid** properties (p.1692). Magnesium salts also act as **osmotic laxatives** (see Constipation, p.1693); the salts generally used for this purpose are magnesium sulfate (an oral dose of 5 to 10 g in 250 mL of water being given for rapid bowel evacuation) and magnesium hydroxide (p.1743).

Parenteral magnesium sulfate has some specific uses. It is used for the emergency treatment of some **arrhythmias** such as torsade de pointes (see below) and those associated with hypokalaemia (p.1669). The usual dose is 2 g of magnesium sulfate (8 mmol of magnesium) given intravenously over 10 to 15 minutes and repeated once if necessary.

Parenteral magnesium sulfate is also used for the prevention of recurrent seizures in pregnant women with **eclampsia** (see below). Debate continues as to which dosage regimen is most appropriate. Typically an intravenous loading dose of 4 g of magnesium sulfate (16 mmol of magnesium) is given over 10 to 15 minutes. This is then followed by either an infusion of 1 g (4 mmol magnesium) per hour (for at least 24 hours after the last seizure) or by deep intramuscular injection of 5 g (20 mmol magnesium) into each buttock then

5 g intramuscularly every 4 hours (for at least 24 hours after the last seizure). Should seizures recur under either regimen, then an additional intravenous dose of 2 to 4 g can be given. It is essential to monitor for signs of hypermagnesaemia, and to stop magnesium dosage should this occur. Doses should be reduced in renal impairment.

The use of magnesium sulfate in **acute myocardial infarction** and **premature labour** is discussed below.

Dried magnesium sulfate has been used in the form of Magnesium Sulphate Paste (BP 2008) as an application to inflammatory skin conditions such as boils and carbuncles, but prolonged or repeated use may damage the surrounding skin.

◊ General references.

1. McLean RM. Magnesium and its therapeutic uses: a review. *Am J Med* 1994; **96:** 63–76.
2. Fawcett WJ, *et al.* Magnesium: physiology and pharmacology. *Br J Anaesth* 1999; **83:** 302–20.
3. Fox C, *et al.* Magnesium: its proven and potential clinical significance. *South Med J* 2001; **94:** 1195–1201.
4. Gums JG. Magnesium in cardiovascular and other disorders. *Am J Health-Syst Pharm* 2004; **61:** 1569–76.

Anaesthesia. Magnesium sulfate has been used to prevent the undesirable haemodynamic response sometimes associated with intubation (p.1900). It has also been tried in the treatment of postanaesthetic shivering (p.1779).

Arrhythmias. Cardiac function is strongly influenced by electrolyte concentrations and some cardiac arrhythmias (p.1160) may be associated with magnesium deficiency. Parenteral magnesium has a role in the management of torsade de pointes and some other arrhythmias, and has also been used to prevent postoperative atrial fibrillation. However, for the suggestion that it did not have an antiarrhythmic effect in patients with myocardial infarction see Myocardial Infarction, below.

Further references.

1. Frick M, *et al.* The effect of oral magnesium, alone or as an adjuvant to sotalol, after cardioversion in patients with persistent atrial fibrillation. *Eur Heart J* 2000; **21:** 1177–85.
2. Stuhlinger HG, *et al.* Der Stellenwert von Magnesium bei Herzrhythmusstorungen. *Wien Med Wochenschr* 2000; **150:** 330–4.
3. Piotrowski AA, Kalus JS. Magnesium for the treatment and prevention of atrial tachyarrhythmias. *Pharmacotherapy* 2004; **24:** 879–95.
4. Shiga T, *et al.* Magnesium prophylaxis for arrhythmias after cardiac surgery: a meta-analysis of randomized controlled trials. *Am J Med* 2004; **117:** 325–33.
5. Alghamdi AA, *et al.* Intravenous magnesium for prevention of atrial fibrillation after coronary artery bypass surgery: a systematic review and meta-analysis. *J Card Surg* 2005; **20:** 293–9.
6. Miller S, *et al.* Effects of magnesium on atrial fibrillation after cardiac surgery: a meta-analysis. *Heart* 2005; **91:** 618–23.

Eclampsia and pre-eclampsia. Parenteral magnesium sulfate has become the preferred treatment for seizures associated with **eclampsia** (p.470). Studies and systematic reviews have shown it to be more effective than phenytoin,[1,2] diazepam,[1,3] or lytic cocktail,[4] as well as causing fewer adverse effects. Its advantages included a rapid effect and lack of sedation in the mother or the infant.[5] It was also considered to have a wide safety margin with the added security of calcium gluconate being an easily available antidote should overdose occur. Subsequent meta-analysis[6] and systematic review[2-4] reinforced this favourable view.

Magnesium sulfate may also be used to prevent eclampsia in **pre-eclamptic** patients; trials have shown it to be more effective than phenytoin,[7] or nimodipine.[8] A randomised placebo-controlled study[9] involving over 10 000 women in 33 countries found that treatment with magnesium sulfate approximately halved the risk of developing eclampsia; the number of maternal deaths was also less in the treatment group although the differences in risk between this group and the placebo group were not significant.

Despite some concerns about the effects on the fetus of magnesium sulfate use in premature labour, (see below), many,[10,11] including WHO, consider magnesium sulfate the drug of choice for both treatment and prevention of eclampsia. Moreover, follow-up studies of the international study mentioned above found that it was not associated with an increased risk of death or disability in the children at 18 months[12] and in the mothers at 2 years.[13]

1. The Eclampsia Trial Collaborative Group. Which anticonvulsant for women with eclampsia? Evidence from the Collaborative Eclampsia Trial. *Lancet* 1995; **345:** 1455–63. Correction. *ibid.*; **346:** 258.
2. Duley L, Henderson-Smart D. Magnesium sulphate versus phenytoin for eclampsia. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2003 (accessed 21/06/05).
3. Duley L, Henderson-Smart D. Magnesium sulphate versus diazepam for eclampsia. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2003 (accessed 21/06/05).
4. Duley L, Gulmezoglu AM. Magnesium sulphate versus lytic cocktail for eclampsia. Available in The Cochrane Database of Systematic Reviews; Issue 3. Chichester: John Wiley; 2000 (accessed 21/06/05).
5. Saunders N, Hammersley B. Magnesium for eclampsia. *Lancet* 1995; **346:** 788–9.
6. Chien PFW, *et al.* Magnesium sulphate in the treatment of eclampsia and pre-eclampsia: an overview of the evidence from randomised trials. *Br J Obstet Gynaecol* 1996; **103:** 1085–91.
7. Lucas MJ, *et al.* A comparison of magnesium sulfate with phenytoin for the prevention of eclampsia. *N Engl J Med* 1995; **333:** 201–5.
8. Belfort MA, *et al.* A comparison of magnesium sulfate and nimodipine for the prevention of eclampsia. *N Engl J Med* 2003; **348:** 304–11.
9. The Magpie Trial Collaborative Group. Do women with pre-eclampsia, and their babies, benefit from magnesium sulphate? The Magpie Trial: a randomised placebo-controlled trial. *Lancet* 2002; **359:** 1877–90.
10. Roberts JM, *et al.* Preventing and treating eclamptic seizures. *BMJ* 2002; **325:** 609–10.
11. WHO. Managing complications in pregnancy and childbirth: a guide for midwives and doctors: headache, blurred vision, convulsions or loss of consciousness, elevated blood pressure. Available at: http://www.who.int/reproductive-health/impac/Symptoms/Headache_blood_pressure_S35_S56.html (accessed 18/05/04)
12. Magpie Trial Follow-Up Study Collaborative Group. The Magpie Trial: a randomised trial comparing magnesium sulphate with placebo for pre-eclampsia—outcome for children at 18 months. *BJOG* 2007; **114:** 289–99.
13. Magpie Trial Follow-Up Study Collaborative Group. The Magpie Trial: a randomised trial comparing magnesium sulphate with placebo for pre-eclampsia—outcome for women at 2 years. *BJOG* 2007; **114:** 300–9.

Hypokalaemia. Potassium and magnesium homoeostasis are linked, and hypokalaemia with increased urine potassium excretion may occur in patients with hypomagnesaemia. In this situation, correction of potassium deficit usually requires magnesium to be given as well. Magnesium sulfate at doses greater than those required to correct hypomagnesaemia has been associated with greater improvements in potassium balance than doses just sufficient to correct hypomagnesaemia.[1]

1. Hamill-Ruth RJ, McGory R. Magnesium repletion and its effect on potassium homeostasis in critically ill adults: results of a double-blind, randomized, controlled trial. *Crit Care Med* 1996; **24:** 38–45.

Migraine. Low magnesium concentrations are thought to be important in the pathogenesis of migraine (p.616), but the precise role of magnesium supplementation in the disorder remains to be determined.[1] In a double-blind study,[2] 24 mmol magnesium daily (in the form of magnesium citrate) reduced the incidence of migraine headache by 42% compared with a reduction of 16% with placebo. However, in another similar study,[3] 20 mmol magnesium daily (in the form of magnesium aspartate hydrochloride) was no more effective than placebo in producing a 50% reduction in migraine frequency or intensity. Intravenous magnesium sulfate has shown benefit in the treatment of migraine attacks,[4] especially in those with aura,[5,6] or in patients with low serum-magnesium levels.[7]

1. Mauskop A, Altura BM. Role of magnesium in the pathogenesis and treatment of migraines. *Clin Neurosci* 1998; **5:** 24–7.
2. Peikert A, *et al.* Prophylaxis of migraine with oral magnesium: results from a prospective, multi-center, placebo-controlled and double-blind randomized study. *Cephalalgia* 1996; **16:** 257–63.
3. Pfaffenrath V, *et al.* Magnesium in the prophylaxis of migraine: a double-blind placebo-controlled study. *Cephalalgia* 1996; **16:** 436–40.
4. Demirkaya Ş, *et al.* Efficacy of intravenous magnesium sulfate in the treatment of acute migraine attacks. *Headache* 2001; **41:** 171–7.
5. Bigal ME, *et al.* Intravenous magnesium sulphate in the acute treatment of migraine without aura and migraine with aura: a randomized, double-blind, placebo-controlled study. *Cephalalgia* 2002; **22:** 345–53.
6. Bigal ME, *et al.* Eficácia de três drogas sobre a aura migranosa: um estudo randomizado placebo controlado. *Arq Neuropsiquiatr* 2002; **60:** 406–9.
7. Mauskop A, *et al.* Intravenous magnesium sulphate relieves migraine attacks in patients with low serum ionized magnesium levels: a pilot study. *Clin Sci* 1995; **89:** 633–6.

Myocardial infarction. Magnesium has an important physiological role in maintaining the ion balance in muscle including the myocardium. Magnesium might have an antiarrhythmic effect (see also Arrhythmias, above) and protect the myocardium against reperfusion injury including myocardial stunning (delayed recovery of myocardial contractility function). Intravenous magnesium salts have been used for cardiac arrhythmias and in an overview of studies in patients with suspected myocardial infarction their use, generally within 12 hours of the onset of chest pain, reduced mortality.[1] The beneficial effect on mortality appeared to be confirmed by the LIMIT-2 study[2] in which 8 mmol of magnesium was given by intravenous injection before thrombolysis and followed by a maintenance infusion of 65 mmol over the next 24 hours. Benefit was confirmed at follow-up an average of 2.7 years later;[3] however, there was no evidence of an antiarrhythmic effect. These beneficial effects were not borne out by the larger ISIS-4 study,[4] although there were slight differences in the magnesium regimen and its timing which might have played a part in these contradictory results. In an attempt to resolve the controversy, the MAGIC trial[5] was designed to test the hypothesis that early use of magnesium in a similar dose to that used in the LIMIT-2 study would reduce short-term mortality in patients with ST elevation myocardial infarction. No benefit or harm of magnesium was observed, and at present the routine use of magnesium in myocardial infarction (p.1175) cannot be recommended.

Patients with acute myocardial infarction may have magnesium deficiency and long-term treatment with oral magnesium has been tried, but in one study was associated with an increased risk of adverse cardiac events and could not be recommended for secondary prevention.[6]

1. Teo KK, *et al.* Effects of intravenous magnesium in suspected acute myocardial infarction: overview of randomised trials. *BMJ* 1991; **303:** 1499–1503.
2. Woods KL, *et al.* Intravenous magnesium sulphate in suspected acute myocardial infarction: results of the second Leicester Intravenous Magnesium Intervention Trial (LIMIT-2). *Lancet* 1992; **339:** 1553–8.
3. Woods KL, Fletcher S. Long-term outcome after intravenous magnesium sulphate in suspected acute myocardial infarction: the second Leicester Intravenous Magnesium Intervention Trial (LIMIT-2). *Lancet* 1994; **343:** 816–19.
4. Fourth International Study of Infarct Survival Collaborative Group. ISIS–4: a randomised factorial trial assessing early oral captopril, oral mononitrate, and intravenous magnesium sulphate in 58 050 patients with suspected acute myocardial infarction. *Lancet* 1995; **345:** 669–85.
5. The Magnesium in Coronaries (MAGIC) Trial Investigators. Early administration of intravenous magnesium to high-risk patients with acute myocardial infarction in the Magnesium in Coronaries (MAGIC) trial: a randomised controlled trial. *Lancet* 2002; **360:** 1189–96.
6. Galløe AM, *et al.* Influence of oral magnesium supplementation on cardiac events among survivors of an acute myocardial infarction. *BMJ* 1993; **307:** 585–7.

Porphyria. Magnesium sulfate is one of the drugs that has been used for seizure prophylaxis in patients with porphyria (p.471) who continue to experience convulsions while in remission.

Premature labour. Magnesium sulfate has been given intravenously to suppress initial uterine contractions in the management of premature labour[1-3] (p.2003). Although it has been found to possess similar efficacy to beta$_2$ agonists,[4,5] and is widely used, in particular in the USA, a systematic review[6] concluded it was ineffective at delaying birth or preventing preterm birth. Other magnesium salts have also sometimes been given orally.[7,8] Retrospective observational studies found a lower incidence of cerebral palsy in children with birth-weights of less than 1500 g when mothers were treated with magnesium sulfate for pre-eclampsia, eclampsia or premature labour.[9,10] However, increased total paediatric mortality was noted in an interim analysis of a trial of antenatal magnesium sulfate in preterm labour,[11] and the trial was subsequently stopped. Although they considered the safety of magnesium sulfate well established in gestation at term, the authors cautioned against the use of magnesium sulfate in very preterm labour. Subsequent studies found that magnesium sulfate was associated with increased perinatal mortality in low birth-weight offspring, particularly when doses of more than 48 g were used,[12] and that neonates with intraventricular haemorrhage (p.1050) had mothers with higher serum-magnesium concentrations at delivery.[13] Some studies have commented[14,15] on other results, including trials of magnesium for treatment and prevention of eclampsia (see above), and have concluded, along with a systematic review[6] that its use as a tocolytic increases the risk of infant mortality.

Although magnesium sulfate is widely used, the American College of Obstetricians and Gynecologists does not promote it (or any drug) for first-line tocolysis.[16] It is not recommended in Europe,[17] and some in the USA have called for such use to be stopped.[18,19]

1. Amon E, *et al.* Tocolysis with advanced cervical dilatation. *Obstet Gynecol* 2000; **95:** 358–62.
2. Terrone DA, *et al.* A prospective, randomized, controlled trial of high and low maintenance doses of magnesium sulfate for acute tocolysis. *Am J Obstet Gynecol* 2000; **182:** 1477–82.
3. Katz VL, Farmer RM. Controversies in tocolytic therapy. *Clin Obstet Gynecol* 1999; **42:** 802–19.
4. Wilkins IA, *et al.* Efficacy and side effects of magnesium sulfate and ritodrine as tocolytic agents. *Am J Obstet Gynecol* 1988; **159:** 685–9.
5. Chau AC, *et al.* A prospective comparison of terbutaline and magnesium for tocolysis. *Obstet Gynecol* 1992; **80:** 847–51.
6. Crowther CA, *et al.* Magnesium sulphate for preventing preterm birth in threatened preterm labour. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2002 (accessed 21/06/05).
7. Martin RW, *et al.* Comparison of oral ritodrine and magnesium gluconate for ambulatory tocolysis. *Am J Obstet Gynecol* 1988; **158:** 1440–3.
8. Ridgway LE, *et al.* A prospective randomized comparison of oral terbutaline and magnesium oxide for the maintenance of tocolysis. *Am J Obstet Gynecol* 1990; **163:** 879–82.
9. Nelson KB, Grether JK. Can magnesium sulfate reduce the risk of cerebral palsy in very low birthweight infants? *Pediatrics* 1995; **95:** 263–9.
10. Schendel DE, *et al.* Prenatal magnesium sulfate exposure and the risk for cerebral palsy or mental retardation among very low-birth-weight children aged 3 to 5 years. *JAMA* 1996; **276:** 1805–10.
11. Mittendorf R, *et al.* Is tocolytic magnesium sulphate associated with increased total paediatric mortality? *Lancet* 1997; **350:** 1517–18.
12. Scudiero R, *et al.* Perinatal death and tocolytic magnesium sulfate. *Obstet Gynecol* 2000; **96:** 178–82.
13. Mittendorf R, *et al.* Association between maternal serum ionized magnesium levels at delivery and neonatal intraventricular hemorrhage. *J Pediatr* 2002; **140:** 540–6.
14. Mittendorf R, *et al.* If tocolytic magnesium sulfate is associated with excess total pediatric mortality, what is its impact? *Obstet Gynecol* 1998; **92:** 308–11.
15. Mittendorf R, *et al.* The Magpie trial. *Lancet* 2002; **360:** 1330–1.

16. American College of Obstetricians and Gynecologists Committee on Practice Bulletins. Management of preterm labor (ACOG Practice Bulletin number 43, May 2003). *Obstet Gynecol* 2003; **101:** 1039–47.
17. Di Renzo GC, Roura LC. European Association of Perinatal Medicine-Study Group on Preterm Birth. Guidelines for the management of spontaneous preterm labor. *J Perinat Med* 2006; **34:** 359–66. Also available at: http://www.reference-global.com/doi/pdfplus/10.1515/JPM.2006.073 (accessed 02/07/08)
18. Grimes DA, Nanda K. Magnesium sulfate tocolysis: time to quit. *Obstet Gynecol* 2006; **108:** 986–9.
19. Simhan HN, Caritis SN. Prevention of preterm delivery. *N Engl J Med* 2007; **357:** 477–87.

Pulmonary hypertension of the newborn. Preliminary studies have suggested that intravenous magnesium sulfate may be effective in treating persistent pulmonary hypertension of the newborn, as mentioned on p.1179.

Respiratory disorders. Magnesium sulfate, given intravenously over 20 minutes in doses of 1.2 g to patients with acute exacerbations of chronic obstructive pulmonary disease (p.1112) who had received inhaled salbutamol, appeared to have moderate efficacy.[1]

Infusion of magnesium has been reported to be of benefit in some patients with acute asthma (p.1108), but results have been conflicting;[2-5] meta-analyses of these and other studies concluded that its routine use was not justified, but that it may benefit some patients with severe exacerbations.[6,7] A meta-analysis of 5 studies in children concluded that intravenous magnesium sulfate is likely to be an effective adjunct to standard therapy in the symptomatic treatment of moderate to severe acute childhood asthma.[8] Inhalation of magnesium has also been investigated, either alone or with salbutamol; another meta-analysis considered that it improved pulmonary function, particularly in combination with a beta$_2$ agonist, with the best results seen in more severe cases.[9]

1. Skorodin MS, *et al.* Magnesium sulfate in exacerbations of chronic obstructive pulmonary disease. *Arch Intern Med* 1995; **155:** 496–500.
2. Skobeloff EM, *et al.* Intravenous magnesium sulfate for the treatment of acute asthma in the emergency department. *JAMA* 1989; **262:** 1210–13.
3. Green SM, Rothrack SG. Intravenous magnesium for acute asthma: failure to decrease emergency treatment duration or need for hospitalization. *Ann Emerg Med* 1992; **21:** 260–5.
4. Ciarallo L, *et al.* Intravenous magnesium therapy for moderate to severe pediatric asthma: results of a randomized, placebo-controlled trial. *J Pediatr* 1996; **129:** 809–14.
5. Silverman RA, *et al.* IV magnesium sulfate in the treatment of acute severe asthma: a multicenter randomized controlled trial. *Chest* 2002; **122:** 489–97.
6. Rowe BH, *et al.* Magnesium sulfate for treating exacerbations of acute asthma in the emergency department. Available in The Cochrane Database of Systematic Reviews; Issue 1. Chichester: John Wiley; 2000 (accessed 21/06/05).
7. Alter HJ, *et al.* Intravenous magnesium as an adjuvant in acute bronchospasm: a meta-analysis. *Ann Emerg Med* 2000; **36:** 191–7.
8. Cheuk DKL, *et al.* A meta-analysis on intravenous magnesium sulphate for treating acute asthma. *Arch Dis Child* 2005; **90:** 74–7.
9. Blitz M, *et al.* Inhaled magnesium sulfate in the treatment of acute asthma. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2005 (accessed 18/12/07).

Stroke. Intravenous magnesium sulfate has been investigated for a neuroprotective effect in stroke (p.1185), but results have been largely disappointing.[1]

1. Intravenous Magnesium Efficacy in Stroke (IMAGES) Study Investigators. Magnesium for acute stroke (Intravenous Magnesium efficacy in Stroke trial): randomised controlled trial. *Lancet* 2004; **363:** 439–45.

Tetanus. Magnesium sulfate has been found to minimise autonomic disturbance in ventilated patients and control spasms in non-ventilated patients when used in the treatment of tetanus (p.1901).

References.

1. Attygalle D, Rodrigo N. Magnesium as first line therapy in the management of tetanus: a prospective study of 40 patients. *Anaesthesia* 2002; **57:** 811–17.
2. William S. Use of magnesium to treat tetanus. *Br J Anaesth* 2002; **88:** 152–3.

Preparations

BP 2008: Magnesium Chloride Injection; Magnesium Sulphate Injection; Magnesium Sulphate Mixture; Magnesium Sulphate Paste;
USP 31: Magnesium Gluconate Tablets; Magnesium Sulfate in Dextrose Injection; Magnesium Sulfate Injection.

Proprietary Preparations (details are given in Part 3)
Arg.: Biomag; Magnebe; Magnesoide†; ***Austral.:*** Celloids MP 65; Mag 50†; Magmin; ***Austria:*** Cormagnesin; Emgecard; FX Passage; Magium; Magnesium Diasporal; Magnesulf; Magvital; Mg 5-Longoral; Solumag; Ultra-Mag; ***Belg.:*** Magnespasmyl; Ultra-Mg; ***Braz.:*** Mag-Tab; Magnolat†; Magnoston; Pidomag; Sal Amargo Purificado; ***Canad.:*** Maglucate; Magnolex; Magnorol; Proflavanol C; Slow-Mag†; ***Chile:*** Mag-Tab; ***Cz.:*** Coradol†; Cormagnesin†; Magnerot; Magnesium Diasporal†; Mg 5-Granulat†; Mg 5-Longoral†; ***Fr.:*** Efimag†; Ionimag†; Mag 2; Magnespasmyl; Magnogene; Megamag; Solumag†; Spasmag; Top-Mag; Vivamag†; ***Ger.:*** Basti-Mag; Cormagnesin; FX Passage; Magium; Magnaspart; Magnerot; Magnerot A; magnerot Classic; Magnesiocard; Magnesium Diasporal; Magnesium Verla; Magnesium Verla N; Magnesorot; metamagnesol†; Mg 5-Granulat†; Mg 5-Longoral; Mg 5-Sulfat; Mgnor; Nourymag†; Power Orot; Retterspitz Darmreinigungspulver ST; ***Gr.:*** Mag 2; Solumag; Trofocard; ***Hung.:*** Astat†; Cormagnesin; Magnerot; Magnesiocard; ***India:*** Mag; ***Irl.:*** Magnesium Verla; ***Ital.:*** Actimag†; Mag 2; MG 50; Olimag†; Solumag; ***Mex.:*** Conducat†; Ifupeptol Magnesiado; Magnefusin†; ***Pol.:*** Asmag; Biomag; Laktomag; Laktomag B ; Magnefar; Slow-Mag; ***Port.:*** Cormagnesin; Magnesiocard; Magnesona; Magnespasmil; Magnoral; Metabol-Mg; ***Rus.:*** Cormagnesin (Кормагнезин); Magnerot (Магнерот); ***S.Afr.:*** Be-Lax; Magnesit; SB Laxative Mixture; Slow-Mag; ***Spain:*** Actimag; Magnesioboi; Sulmetin†; ***Switz.:*** Mag 2; Mag-Min; Magnegon; Magnesiocard; Magnesium Biomed; Magnesium Vital; Magnesium-Sandoz; Magnespasmyl†; Magnogene; Mg 5-Granoral; Mg 5-Longoral; Mg 5-Oraleff; Mg 5-Sulfat; Solmag†; ***UK:*** Kest; ***USA:*** Almora†; Chloromag: Mag-G; Mag-SR; Mag-Tab; Magtrate; Slow-Mag.

Multi-ingredient: ***Arg.:*** Anartrit; Antikatarata†; Drenocol†; Magnesia Phosphorica I Oligoplex; Magnesio Incaico; Mylanta Extra; Nervigenol Magnesio†; Noacid Diates; Sigmafem; Sigmaflex; Total Magnesiano con Ginseng; Veraldid; ***Austral.:*** Aspartatol; Bio Magnesium; Bioglan Bioage Peripheral; Caprilate; Cardioplegia A; Cardioplegia Concentrate; Celloid Compounds Magcal Plus; Chelated Cal-Mag; Citri Slim+Trim; Duo Celloids CPMP; Duo Celloids PCMP; Duo Celloids PPMP; Duo Celloids PSMP; Duo Celloids SPMP; Duo Celloids SSMP; Extralife Migrai-Care; Extralife Sleep-Care; K-Mag†; Kali Mag†; Machlor; Mag-Oro; Magnesium Plus†; Magnoplasm; ML 20†; Pro-Shape†; Salvital; Zinvit; Zinvit C; Zinvit G; ***Austria:*** Cascara-Salax; Centramin; Corozell; Elozell; Elozell spezial; Gladixol; Illings Bozner Maycur-Tee†; Mag Kottas May-Cur-Tee; Maycardin K; Trommcardin; Trommgallol; ***Braz.:*** Alcafelol†; Sal de Andrews; ***Canad.:*** Osmopak-Plus; ***Chile:*** Cholinogo; ***Cz.:*** Acne Lotio†; Cardilan; Magne-B ; Solutio Thomas cum Procaino; Tromcardin; ***Fin.:*** Wicnelact; ***Fr.:*** Biopause; Cataridol†; Cemaflavone; Chloro-Magnesion†; Cristopal†; Decramp; Delbiase†; Ionyl; Kaologeais; Karayal; Magne-B ; Osmogel; Phosphoneuros; Prefagyl†; Revitalose; Spasmag; Supro; Thalgo Tonic; Tryptonat; Uvimag B ; ***Ger.:*** Ardeycordal N†; Bascardial†; Biomagnesin; Cardio-Kreislauf-Longoral; Cardioplegin N†; Cordesin; Galacordin; Geo-magnit†; Kalium-Magnesium†; Lacoerdin Mg Plus†; Magium K; Magnerot N; Magnesium compositum†; Movicard; rohasal†; Scordal†; Septacord; Tromcardin; Trophicard; ***Gr.:*** Cardioplegia; Magnesium Sandoz; ***Hong Kong:*** Cardioplegia; Osteocare; ***Hung.:*** Aspacardin†; Magne-B ; Osteocare; Panangin; Tromcardin; Vition; ***India:*** Calcinol; Cotaryl; ***Indon.:*** Cardioplegia; Osteocare; ***Irl.:*** Andrews; Bio-Calcium + D ; ***Ital.:*** Briovitase; Calmason; Fertomcidina-U; Fisioreve; Hiperogyn; Polase; Reocol†; Sedofit; Vagostabil; ***Malaysia:*** Adult Citrex Cal-Mag-D3; Cardioplegia; Junior Citrex Cal-Mag-D3; ***Mex.:*** Chofabol; Cidetox; Dicentril; Gavicid†; Hepedren; Peptocholʼ†; Ulgel; ***Philipp.:*** Osteocare; ***Pol.:*** Aspargin; Bemag; Filomag B ; Maglek B ; Magne-B ; Magne-Balans Plus; Magnefar B ; Magnezytki; Magnokal; Magsolvit B ; Magvit B ; Osteogel; Slow-Mag B ; Wamag; ***Port.:*** Actilam; Miostenil; Polase; ***Rus.:*** Magne B6 (Магне В6); Panangin (Панангин); ***S.Afr.:*** Phytopause BSF; Ultimag; ***Singapore:*** Cardioplegia; Vita Calmag Zn†; ***Spain:*** Darmen Salt; Depurativo Richelet; Eupeptina; Lebersal; Magnesium Pyre; Magnogene; Salmagne; Sugarbil; Sulmetin Papaver; Sulmetin Papaverina†; ***Switz.:*** Acne Lotion; Activital Forte; Kawaform†; Klyx Magnum; Magnesium Complexe; Siesta-1; Vigoran†; ***Thai.:*** Calcioday-D†; Cardioplegia; ***Turk.:*** Osteocare; ***UK:*** Andrews; Pegna; ***USA:*** Chlor-3; Mag-Cal Mega; Mag-SR plus Calcium; Magonate; ***Venez.:*** Calcinor D; Fugras; Kalsis.

Phosphate

Fosfato.

Description. Phosphate is an anion given as various potassium or sodium salts.

Incompatibility. Phosphates are incompatible with calcium salts; the mixing of calcium and phosphate salts can lead to the formation of insoluble calcium-phosphate precipitates. Incompatibility has also been reported with magnesium salts.

Monobasic Potassium Phosphate

Dihydrogenfosforečnan draselný; E340; Kalii dihydrogenophosphas; Kalio-divandenilio fosfatas; Kálium-dihidrogén-foszfát; Kaliumdivätefosfat; Kaliumdivetyfosfaatti; Monopotassium Phosphate; Phosphate monopotassique; Potasio, dihidrogenofosfato de; Potassium Acid Phosphate; Potassium Biphosphate; Potassium Dihydrogen Phosphate; Potasu diwodorofosforan. Potassium dihydrogen orthophosphate.

KH_2PO_4 = 136.1.
CAS — 7778-77-0.

Pharmacopoeias. In *Eur.* (see p.vii). Also in *USNF.*
Ph. Eur. 6.2 (Potassium Dihydrogen Phosphate). A white or almost white, crystalline powder or colourless crystals. Freely soluble in water; practically insoluble in alcohol. A 5% solution in water has a pH of 4.2 to 4.5.
USNF 26 (Monobasic Potassium Phosphate). Colourless crystals or a white granular or crystalline powder. Is odourless. Freely soluble in water; practically insoluble in alcohol. pH of a 1% solution in water is about 4.5. Store in airtight containers.

Equivalence. Each g of monobasic potassium phosphate represents about 7.3 mmol of potassium and of phosphate.

Dibasic Potassium Phosphate

Dikalii phosphas; Dikalio fosfatas; Dikaliumfosfaatti; Dikaliumfosfat; Dikálium-hidrogén-foszfát; Dipotasio, hidrogenofosfato de; Dipotassium Hydrogen Phosphate; Dipotassium Phosphate; Dipotasu wodorofosforan; E340; Hydrogenofosforečnan draselný; Kalii Hydrogenophosphas; Phosphate dipotassique; Potassium Phosphate. Dipotassium hydrogen orthophosphate.

K_2HPO_4 = 174.2.
CAS — 7758-11-4.

Pharmacopoeias. In *Eur.* (see p.vii) and *US.*
Ph. Eur. 6.2 (Dipotassium Phosphate; Dipotassium Hydrogen Phosphate BP 2008). A very hygroscopic, white or almost white powder or colourless crystals. Very soluble in water; very slightly soluble in alcohol. Store in airtight containers.
USP 31 (Dibasic Potassium Phosphate). Colourless or white, somewhat hygroscopic, granular powder. Freely soluble in water; very slightly soluble in alcohol. pH of a 5% solution in water is between 8.5 and 9.6.

Equivalence. Each g of dibasic potassium phosphate represents about 11.5 mmol of potassium and 5.7 mmol of phosphate.

Monobasic Sodium Phosphate

Dihydrogenfosforečnan sodný; E339; Monobazik Sodyum Fosfat; Natrii dihydrogenophosphas; Natrio-divandenilio fosfatas; Natrium Phosphoricum Monobasicum; Nátrium-dihidrogén-foszfát; Natriumdivätefosfat; Natriumdivetyfosfaatti; Phosphate monosodique; Sodio, dihidrogenofosfato de; Sodium Acid Phosphate; Sodium Biphosphate; Sodium Dihydrogen Phosphate; Sodu diwodorofosforan; Sodyum Dihidrojen Fosfat. Sodium dihydrogen orthophosphate.

$NaH_2PO_4.xH_2O$.
CAS — 7558-80-7 (anhydrous monobasic sodium phosphate); 10049-21-5 (monobasic sodium phosphate monohydrate); 13472-35-0 (monobasic sodium phosphate dihydrate).
ATC — A06AD17; A06AG01.
ATC Vet — QA06AD17; QA06AG01.

Pharmacopoeias. In *Eur.* (see p.vii) (with $2H_2O$); in *Chin.* (with $1H_2O$). *Br.* also includes monographs for the anhydrous and monohydrate forms. *US* permits the anhydrous, monohydrate, and dihydrate forms.
Ph. Eur. 6.2 (Sodium Dihydrogen Phosphate Dihydrate; Natrii Dihydrogenophosphas Dihydricus). A white or almost white powder or colourless crystals. Very soluble in water; very slightly soluble in alcohol. A 5% solution in water has a pH of 4.2 to 4.5.
The BP 2008 gives Sodium Acid Phosphate as an approved synonym.
BP 2008 (Anhydrous Sodium Dihydrogen Phosphate). A white, slightly deliquescent, crystals or granules. Very soluble in water; very slightly soluble in alcohol. A 5% solution in water has a pH of 4.2 to 4.5.
BP 2008 (Sodium Dihydrogen Phosphate Monohydrate). A white powder or colourless crystals. Very soluble in water; very slightly soluble in alcohol. A 5% solution in water has a pH of 4.2 to 4.5.
USP 31 (Monobasic Sodium Phosphate). It contains one or two molecules of water of hydration, or is anhydrous. Colourless crystals or white crystalline powder. Is odourless and is slightly deliquescent. Freely soluble in water; practically insoluble in alcohol. Its solutions are acid to litmus and effervesce with sodium carbonate. pH of a 5% solution in water of the monohydrate form is between 4.1 and 4.5.

Equivalence. Each g of monobasic sodium phosphate (anhydrous) represents about 8.3 mmol of sodium and of phosphate. Each g of monobasic sodium phosphate (monohydrate) represents about 7.2 mmol of sodium and of phosphate. Each g of monobasic sodium phosphate (dihydrate) represents about 6.4 mmol of sodium and of phosphate.

Dibasic Sodium Phosphate

Dibazik Sodyum Hidrojen Fosfat; Dinatrii phosphas; Dinatrio fosfatas; Dinatriumfosfaatti; Dinatriumfosfat; Dinátrium-hidrogén-foszfát; Disodio, hidrogenofosfato de; Disodium Hydrogen Phosphate; Disodium Phosphate; Disodu fosforan; Disodu wodorofosforan; Disodyum Hidrojen Fosfat; E339; Hydrogenofosforečnan sodný; Natrii Hydrogenophosphas; Natrii Phosphas; Natrii Phosphatis; Natriumfosfaatti; Natriumfosfat; Phosphate disodique; Sodium Phosphate. Disodium hydrogen orthophosphate.

$Na_2HPO_4.xH_2O$.
CAS — 7558-79-4 (anhydrous dibasic sodium phosphate); 10028-24-7 (dibasic sodium phosphate dihydrate); 7782-85-6 (dibasic sodium phosphate heptahydrate); 10039-32-4 (dibasic sodium phosphate dodecahydrate).
ATC — A06AD17; A06AG01; B05XA09.
ATC Vet — QA06AD17; QA06AG01; QB05XA09.

Pharmacopoeias. In *Eur.* (see p.vii), *Jpn,* and *US.* The pharmacopoeias may specify one or more states of hydration; monographs and specifications can be found for the anhydrous form (Na_2HPO_4 = 142.0), the dihydrate ($Na_2HPO_4.2H_2O$ = 178.0), the heptahydrate ($Na_2HPO_4.7H_2O$ = 268.1), and the dodecahydrate ($Na_2HPO_4.12H_2O$ = 358.1), although not necessarily all will be found in any one pharmacopoeia.
Ph. Eur. 6.2 (Disodium Phosphate, Anhydrous; Dinatrii Phosphas Anhydricus; Anhydrous Disodium Hydrogen Phosphate BP 2008). A white or almost white, hygroscopic powder. Soluble in water; practically insoluble in alcohol. A 5% solution in water is slightly alkaline. Store in airtight containers.
Ph. Eur. 6.2 (Disodium Phosphate Dihydrate; Dinatrii Phosphas Dihydricus; Disodium Hydrogen Phosphate Dihydrate BP 2008). A white or almost white powder or colourless crystals. Soluble in water; practically insoluble in alcohol. A 5% solution in water is slightly alkaline.
The BP 2008 gives Sodium Phosphate Dihydrate as an approved synonym.
Ph. Eur. 6.2 (Disodium Phosphate Dodecahydrate; Dinatrii Phosphas Dodecahydricus; Disodium Hydrogen Phosphate Dodecahydrate BP 2008). Colourless, transparent, very efflorescent crystals. Very soluble in water; practically insoluble in alcohol. A 10% solution in water is slightly alkaline.